THE *Petroleum* Engineer **Management Edition**

Exploration—Drilling—Producing • Refining—Petrochemical—Gas Processing • Oil and Gas Pipelining

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exploration picture brightens

Not since the end of World War II has the oil outlook been as favorable as it is today. Garbage dumps all over the nation are littered with "crystal balls" as the industry exceeds all predictions made just six months ago by the "seers." Some forecast 52,000 wells and up would be drilled this year; demand for domestic crude was set at 3½ to 5 per cent gain over last year's production. At the end of the first half, it appears that even the highest estimates might be exceeded if the pace continues. Mere extrapolation of these two curves forecast a possible 54,000 or more wells; more than 3 billion barrels total demand. To those connected with producing and drilling, with refining and pipelining the picture is mighty pretty.

But how about the "oil finders," that mighty important segment of the industry who must point their finger at places where petroleum might exist? Until recent months, the situation has been less than bright, if we consider the number of geophysical crews active as a yardstick. Since the fall of 1953, total geophysical crews took a downward trend that continued until early this year. For the first time in many moons, the curve is on the upswing. Our exploration vehicle is getting back into gear. Why the lag behind demand and drilling? Are we just now waking up?

Dispossessed of our crystal ball, perhaps a look at some facts might tell an interesting story. The ratio of reserves to annual consumption of petroleum has remained fairly steady around the 13 mark for a number of years. Reserves are the lifeblood of an oil operator, and, for that matter, of the nation whose economy depends highly upon oil. If our higher demand lessens this ratio, something must be done about it in a hurry to rectify the situation, for it takes several years from the start of an exploration program to a field discovery. Based on past records, we must find about 1.6 barrels of reserves for every barrel of oil we produce to maintain our present ratio of reserves to demand. This means that we must uncover nearly 5 billion barrels this year! When demand accelerates, our oil finding effort must accelerate even greater. Therefore, the demand for domestic oil is apparently strong enough to have a marked effect upon the increase experienced recently in geophysical activity.

Another all-important factor is the cost of finding new oil. No company, unless financially powerful, can withstand for an extended time to find and produce its oil at a loss or even at the break-even point. There must be a profit. It is interesting to note that in 1953 figures indicate that it cost about $1.80 to find a new barrel of oil that year; last year, the cost dropped to around $1.50 for the national average. Although there were no Scurry Counties or Pembinas, there were a record number of discoveries that had their impact on the total. The success ratio was high, too. So, when we couple the demand outlook and the reserve ratio situation with the current cost to find oil, the sum must lead to a stepped-up search for more oil. The exploration picture is brightening month by month, allowing the "oil-finder" to shoulder his tremendous responsibility.

J. E. KASTROP.

NEW LINCOLN PLANT CREATED BY INCENTIVE INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

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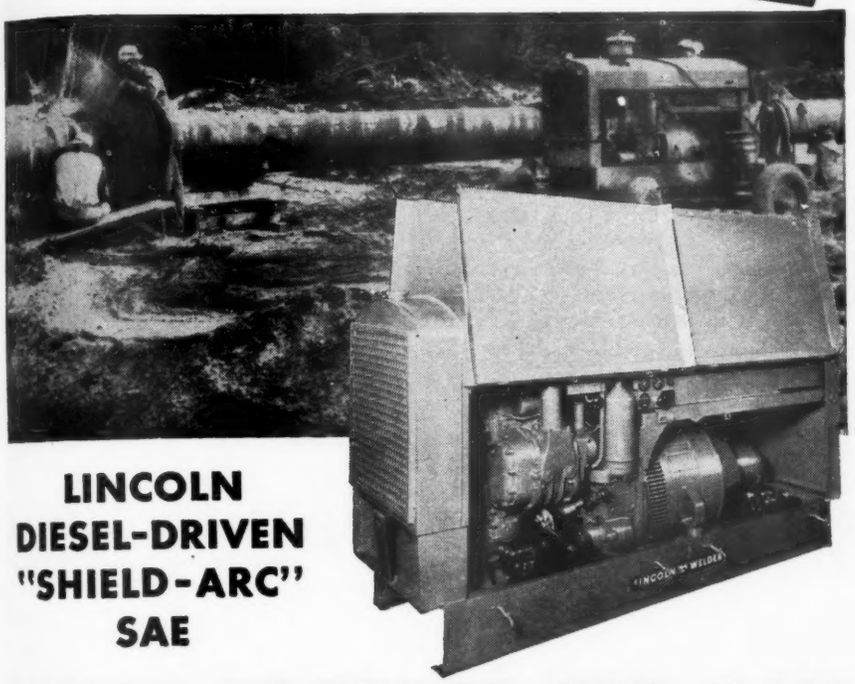

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Fig. 1. *Diesel-driven "Shield-Arc" welders on Linconditioning line. Welders are completely disassembled at start of rebuilding process.*

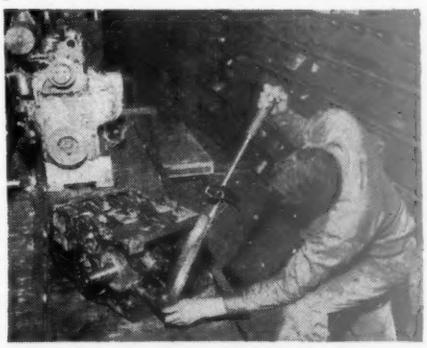

Fig. 2. *Welders are carefully reassembled on Linconditioning line. Rebuilt welders provide another full service life.*

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HIGHLIGHTS ★ ★ ★

Digest of News and Comment

A foundation has been formed in Portugal from the estate of C. S. Gulbenkian. The late Gulbenkian held a 5 per cent interest of all oil produced by the Iraq Petroleum Company, and its associated companies in the Middle East. The foundation is being established with charitable, artistic, educational and scientific purposes for the benefit of all nationalities.

★ ★ ★

State of Louisiana has approved the leasing of more than 25,000 acres of its submerged lands in receipt of bonuses totaling $2,049,626. Request for the leases were made at the state's July 12 auction. Successful bidders include Shell, British-American, Union of California and Louisiana Land and Exploration (together), Tennessee Gas Transmission, and Cities Service. Louisiana will take bids on September 14 on 45 additional tracts, mostly inland.

★ ★ ★

Soviet Russia has returned Europe's most lucrative oil fields and refineries to Austria in accordance with a World War II peace treaty signed May 15. Included in the return are some 1250 wells in the Zisterdorf oil fields and 28 oil refineries, for which Austria must repay Russia with $150,000,000 in goods and 10,000,000 tons of oil in the next 10 years. The fields were developed years ago by the old Socony Vacuum and Royal Dutch Shell companies prior to Nazi annexation of that country in 1938.

★ ★ ★

Oil leasing on some 7,000,000 acres of government-owned land has been cleared with the passage of the House bill No. 100. The bill, just signed into law by President Eisenhower, covers land previously held for water-power project sites.

★ ★ ★

One hundred and twenty-two fatal accidents and permanent disabilities occurred in the oil industry last year, the Bureau of Mines reports. Percentagewise, 1954 has the best injury record since statistics were first kept 13 years ago. Injuries were less frequent in the natural gasoline, pipe line oil, marine transportation, refining and marketing—but injuries were less severe in the exploration, natural gasoline, marine transportation and refining segments. Accident information came from records of 2939 companies in the U. S.

★ ★ ★

Demand for all major oil products continues high, with some estimates placing the increase as much as 9 per cent above the year-ago level. By quarters, primary demand has run consistently higher this year: about 5 per cent for the first three months, 7 for the second. Resulting demand for crude has led buyers to ask state oil commissions for additional oil for the month of September, to give producers their first increase in crude proration since June.

★ ★ ★

Office of Defense Mobilization has ceased granting of quick tax write-offs for all petroleum programs. No action will be taken on the certificates now pending, although recommendation for the project may have come from the Interior's Office of Oil and Gas. Only one phase of the industry has escaped the rapid amortization suspension—alkylate production, vital to aviation gasoline output. ODM officials state that all future programs must relate to defense needs.

★ ★ ★

Expansion scheduled in 1956 by the Cities Service refinery in Ponca City, Oklahoma, may cost $5,000,000, officials say. Plans include revamping the crude vacuum unit and addition of a Rexforming unit. Project, when completed, would increase the plant's crude processing capacity from 25,000 to 35,000 bbl a day.

★ ★ ★

Atomic particle accelerators have been purchased by Shell and Atlantic Refining for use in petroleum processing research by the two companies. Atlantic has unveiled a unit at its Philadelphia, Pennsylvania plant. Shell expects completion of its atom smasher by June, 1956 at its Emeryville, California research lab. One is already in operation at Shell's Houston, Texas lab. The units are being used to turn out experimental quantities of rocket fuel, recreate movement and formation of the earth's structure, and exploit product possibilities.

Mobil Oil of Canada, Ltd., has been adopted as the new name of the former Socony Vacuum Oil Company of Canada, Ltd., in line with recent name change of the parent company to Socony Mobil Oil Company.

★ ★ ★

Rotary rig count in the U. S. and Canada was at its 1955 high in mid-August. The 2952 active rigs was one above the previous record week of August 8. To bolster the outstanding record were all-time peaks established in the Rocky Mountain and Western Canadian districts. There is a current lead of 417 running rigs over the total number counted in the same period last year.

★ ★ ★

Gulf Oil Corporation is planning to extend its high levels of exploration and production into 1956, which at present indicate that operations will surpass those of any previous year. Last year Gulf, alone or jointly with other companies, drilled 1070 wells in the U. S.—300 more than in 1953.

★ ★ ★

Breach of contract charges have been filed by The Texas Company against the Oil, Chemical and Atomic Workers International Union, CIO, and Westville (New Jersey) Local 12-638, OCAWIU-CIO. Texaco is seeking $74,266 in actual damages which resulted from an alleged strike and work stoppage due to support given a strike of the National Maritime Union against the company's tankship operations. Texaco is also asking the court to decide, in the interest of employee relations, the difference of opinion between the company and the union as to whether or not the contract had actually been breached.

★ ★ ★

Oil production in Texas has paced U. S. demand this year with a 7 per cent increase over the first six months of 1954, Texas Railroad Commission reports. Production in that state topped last year's level by 48,000,000 bbl. The commission has set the state's crude allowable for September at 3,021,086 bbl per day, with continuance of the present 15-day schedule, resulting in an increase of 67,000 bbl per day over August.

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REPRESENTATIVES IN ALL PRINCIPAL CITIES

Tidewater Associated has ordered what is believed to be the largest coastwise oil-carrying tow barge in the world. The vessel, 290 ft in length, will have a capacity of more than 2,000,000 gal. It will see service on the West Coast.

★ ★ ★

Rifle, Colorado, shale oil plant has appropriated $1,000,000 for operation during the present fiscal year. Nearly $100,000 of the amount will be used for putting retorting, refining and research facilities in "standby" condition. Other money will be used to continue mining work. Officials say the plant will not be put up for sale.

★ ★ ★

Spending in Canada's mining and oil industries has jumped 28 per cent over the 1954 figure, according to Ottawa's mid-year survey of capital spending plans. Increase was seen in all Canadian business ventures, although at not nearly such a high rate.

★ ★ ★

Name of monthly safety publication for Houston, Texas, area employees of Gulf Oil Company has been changed to Gulf Oilmanac. In publication since 1930, the magazine has grown from three mimeographed sheets to its modern pictorial type format, reflecting Gulf's (as well as the industry's) increasing emphasis on safety, accident prevention and employee welfare.

★ ★ ★

Jersey Standard claims to have made the "biggest petroleum sale in history," promising delivery of fuel oil to 8 new British government-owned electric generating stations near Fawley, England. First delivery is slated in less than 4 months to plants originally designed to be coal-fired, and total fuel consumption is expected to run around 210,000,000 bbl within the contract period of 10 years. The sale has spurred similar deals between Shell-Mex and British Petroleums, Ltd., and Britain's socialized electric industry. Coal miners are lacking, and the English are importers of coal.

★ ★ ★

Natural gas, which has been producing more stomach ulcers than anything else for human beings lately, is being used in increasing amounts in the manufacture of urea, a chemical food in plants and animals. Rich in nitrogen and protein, it is becoming a major plant nutrient as a fertilizer, and as a livestock feed. About 30 per cent of urea to be produced this year, totaling nearly 300,000 tons, is being used in plastics. New plants are being constructed which will raise 1956 production to about 500,000 tons.

★ ★ ★

Socony Mobil Oil Company, in a joint effort with 7 other firms, will begin construction this fall of the first nuclear reactor to be owned and operated by private industry for research and humanitarian fields. Plans call for operations to start within a year. Socony Mobil, aside from its part in construction of the reactor, will establish a nuclear research center owned and operated by its research labs. Site for the facilities has not been selected.

★ ★ ★

Bureau of Mines has predicted this year's petroleum demand will be 6 per cent above the 1954 total. Its forecast would set 1955 demand at 3,136,000,000 bbl. The bureau's January prediction placed the year's demand only 3 per cent over last year.

★ ★ ★

Oil industry in California, which has already spent over $24,000,000 on installation of smog control equipment, will soon be expected to spend an additional $7,000,000 on vapor recovery at wholesale marketing outlets. The last development comes as a result of new Los Angeles County regulations calling for installation of closed vapor recovery systems at all refinery and terminal loading racks, service stations, and on gasoline tank trucks and trailers. Other recent developments indicate that manufacturers atre testing anti-vapor producing car and truck mufflers.

★ ★ ★

Sale of LP gas is expected to increase "at least" 7 to 8 per cent annually for the next five years, Warren Petroleum officials predict. Growth of the industry has been phenomenal since 1940, now having nearly 9,000,000 consumers. Many businesses have claimed sales increases as high as 33 per cent this year, as LP-gas service stations and various marketing outlets continue to increase in number. Warren and Phillips recently announced fractional-cent increases on the fuel in most marketing areas.

Beauty contests, fashion shows and films will highlight the eighth annual Oil Progress Week beginning October 9. Stress will be put on the independent status of the 42,000 oil businesses and 200,000 service stations in this country. Several states have made official proclamations concerning the special week.

★ ★ ★

First Cuban Congress on Petroleum will meet on the campus of the Universidad de Oriente in Santiago October 21-23. Groups from Holland, Mexico, Canada, Venezuela and Argentina, as well as from the U. S., will be present at the University sponsored sessions, which mark Cuba's rapid entry into oil exploration, research and development.

★ ★ ★

Cities Service Oil Company has awarded 21 scholarships to the sons and daughters of its employees through the Henry L. Doherty Educational Foundation, a company-supported organization. Renewed scholarships were also granted to 38 additional students enabling them to continue their college studies. These are renewable each year for a four-year period on the basis of scholastic achievement, citizenship and extracurricular activities, and need not be in petroleum-allied fields.

★ ★ ★

Special petroleum-base wax has found a new use in the meat-packaging industry. Increased sales have encouraged use of the process, and several large packers are considering large-scale trial of the yellow waxing of quick-frozen meats. McAllister Dairy Farms, Inc., of Warren, Ohio, has found that the process cuts packaging time considerably, resulting in prices as much as 15 per cent lower. Some chain stores report packaging costs normally run 9 cents per pound.

★ ★ ★

Alberta, Canada's greatest source of revenue since April, 1946, has been the crown reserve lease sales. These have brought in $156,485,000 in the last nine years. Second highest has been royalties from oil and natural gas production, netting over $80,000. Oil and gas lease fees and rentals, third rating source of income, brought in $67,000,000. Oil and gas rights since 1946 have enriched Alberta by some $405,000,000.

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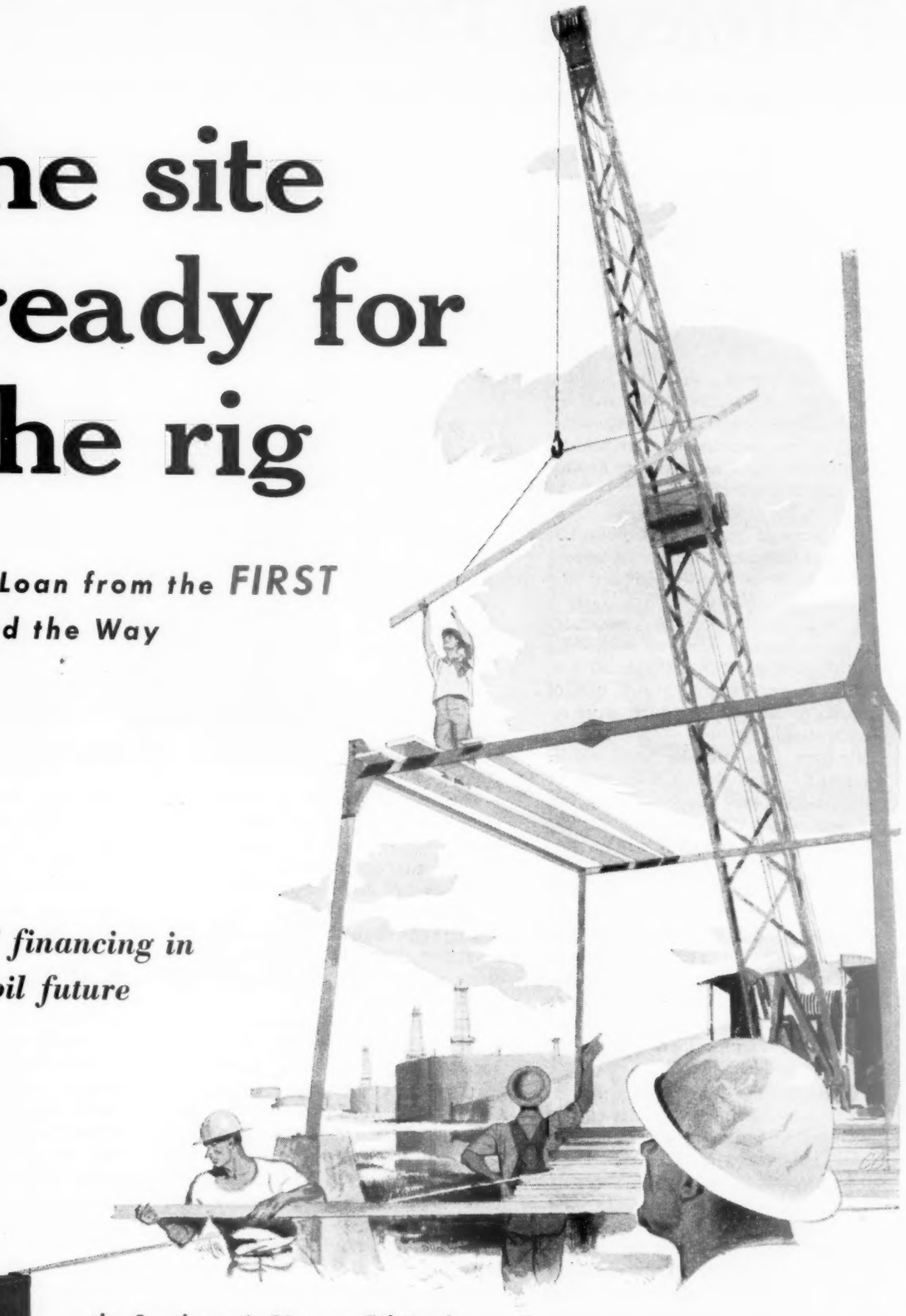

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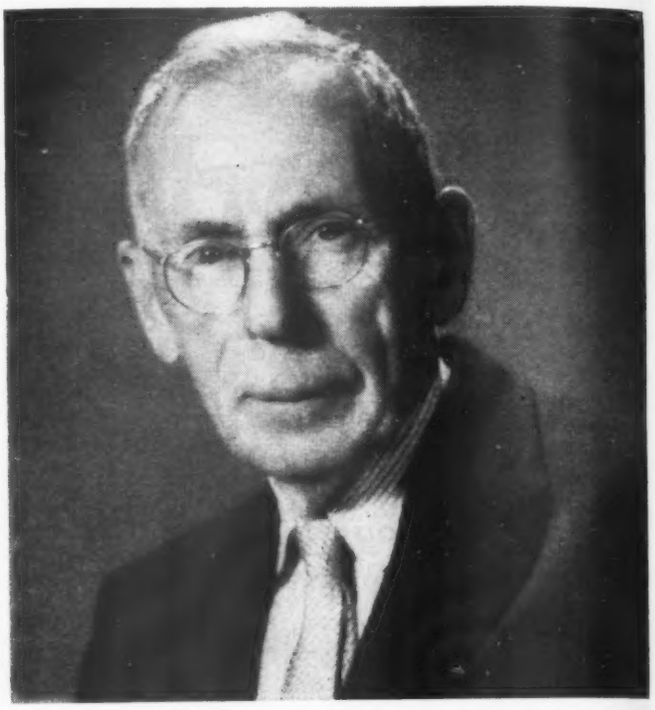
Petroleum Profile



BURTON McCOLLUM

YOU can't help envying Burton McCollum no matter where you stand. He's already had 75 years of possessing and enjoying a pioneering mind with an insatiable curiosity about the physical world. He has the background and energy to push farther than most into the earth's mysteries. The disappointments which were numerous throughout his life were not enough to deter him from continued search for more information. This enviable characteristic has enabled him to achieve material successes necessary to finance his endless research.

Today, he works long hours seven days a week as head of McCollum Exploration Company, which he organized in 1929 in Houston, Texas, and McCollum Laboratories, Inc., which was established later. His associates say he is hard to keep up with. Not only does he go at a fast pace all day, but he never seems to run out of theories or ideas upon which more research should be done.

Perhaps you must be born with a pioneering mind, but it does you no good unless you develop it. Young Burton McCollum was doing that while a student at high school when he sold his first patent for $250. He went on to the University of Kansas where he received an electrical engineering degree. He worked in a power plant operation, taught engineering at Kansas University, and then joined the National Bureau of Standards in 1909, where for more than a decade he did research in various fields of physics and electrical engineering.

It was during World War I that research was begun that later meant much to the future of geophysics and the oil industry. McCollum, Dr. W. P. Haseman, head of the physics department at the University of Oklahoma, Dr. E. A. Eckhardt and Dr. J. C. Karcher, both of the technical staff of the Bureau of Standards, and Captain L. P. Woods, worked on a project that used sound waves to find enemy artillery. It was this first groping into earth waves that later brought about their use in exploring subsurface geology. The idea was appealing enough to Haseman for him to obtain financial backing from oil men. In 1921, the Geological Engineering Company was organized by a group of independent oil operators, and Haseman, Eckhardt, Karcher and McCollum comprised the research staff.

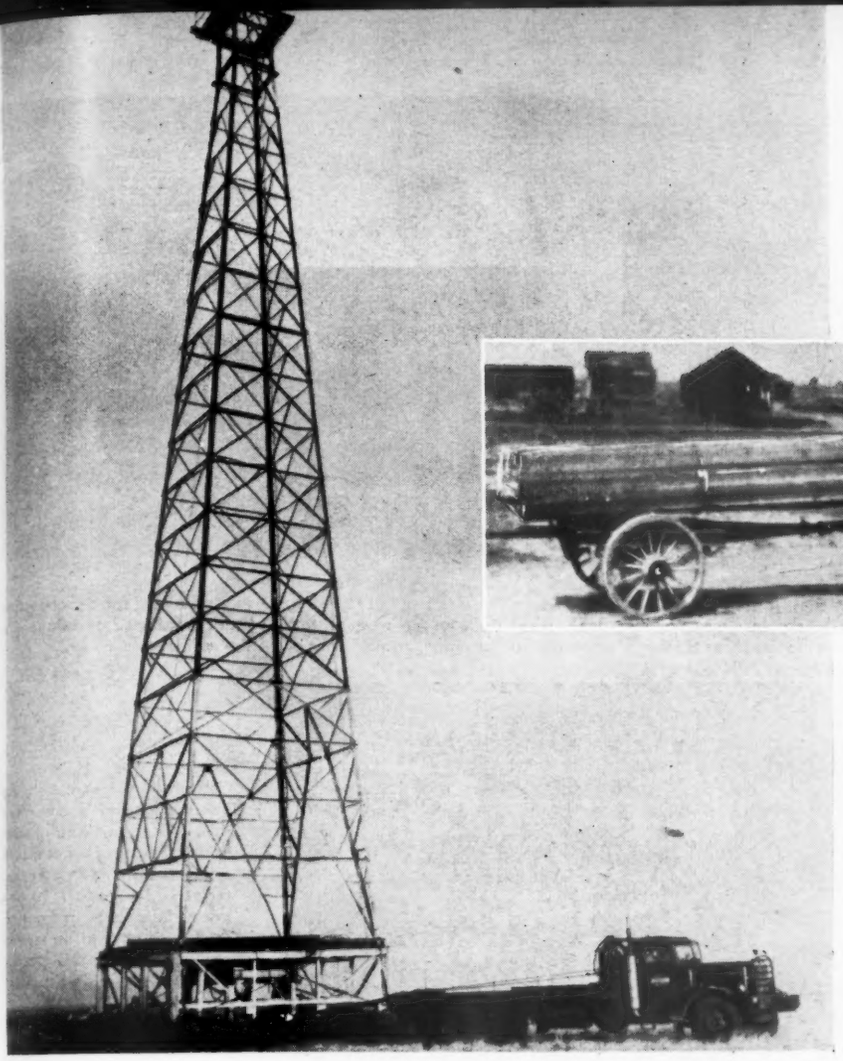
The company failed to impress the oil industry and lasted only a year. McCollum assumed liabilities of the firm in order to protect his patent applications and after further research in 1923 he was able to obtain patents on several seismic methods that embraced basic techniques in both reflection and refraction methods which later developed into patents.

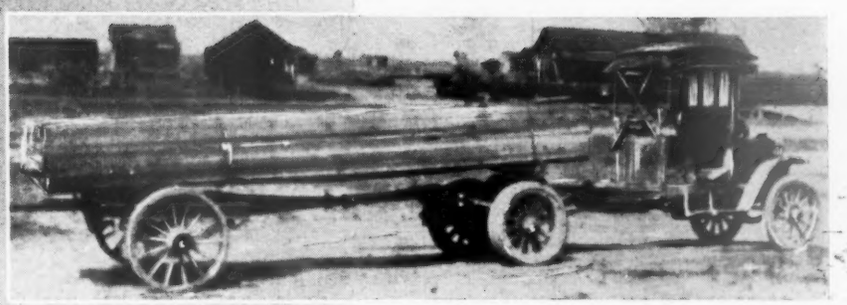
His work drew the attention of Atlantic Refining Company which engaged him to do some exploration work for its subsidiary, Cortez Oil Company, in Mexico. After long years of constant work, his seismograph findings paid off. The Aguada No. 6, first well located by seismic methods, checked geologically almost exactly with McCollum's predictions. The next location made by the seismograph was the Zacamixtle 199 which came in as a 400-bbl a day producer, the first producing well ever located by the seismograph.

McCollum continued his work with Atlantic in Mexico and later shifted his interests to the Gulf Coast where he organized his own company. He developed methods of profiling shallow salt domes, including field techniques and mathematical processes for interpretation of records. Several Gulf Coast salt domes, including Barbers Hill, High Island and Fannett were contoured successfully by these methods in 1925 and 1926. McCollum also pioneered the development of special methods for making deep profiles on salt domes through the use of existing wells, and made the first seismic location of wells to be drilled through overhanging salt. More recently, he developed the Geograph, which utilizes new methods of seismic exploration involving a falling weight as the source of seismic waves.

McCollum is one of those rare individuals possessed of a photographic mind that astounds his associates by making complicated calculations without the aid of references, pencil or paper.

His contributions have been instrumental in locating billions of barrels of oil, but McCollum has never profited directly from oil or gas production; he has financed his extensive research by putting his profits from geophysical contracting into research to investigate seismic phenomena and to improve geophysical techniques. He was more concerned in his research for new knowledge than he was in filling his pocketbook. What Burton McCollum has already accomplished is more than a life-time's contribution to scientific knowledge. The oil industry should be glad we have had the benefit of the energies and curiosities of such a man.





— *Gulf Oil.*

Gulf Oil Company supplied the photo above, which is believed to have been made in 1903. This is an old service truck with what is thought to be a Feigelson trailer. The load of lumber was probably to be used to build one of the wood derricks of that day. Fifty odd years later a Kenworth truck (left) takes off across West Texas to move a large steel derrick already built. Sometimes the drilling equipment, including heavy drawworks, is left on the derrick floor. The work horses of the petroleum industry have grown stouter and more versatile along with other equipment.

TRUCKS: Magic Carpet and Muscles of the Petroleum Industry

THE United States Post Office is celebrating in 1955 the 50th anniversary of the trucking industry with the special stamp shown here. In 1905 about 1000 trucks and buses were registered in the United States; this year registration will top 10,000,000.

These figures, however, are not the ones that tell the big story. The trucks of 1905 were fairly equal rivals of horse-drawn vehicles; the modern truck engine makes the term "horsepower" sound old-fashioned for no number of horses can rival its performance in power and maneuverability.

It was natural that the oil industry, with its huge problem of transportation, should be among the first to try out the new-fangled trucks of early days. The 1903 truck of Gulf Oil Company shown in the photograph was perhaps hauling lumber for a derrick. Some modern trucks, like the other picture, can take off across country pulling a steel derrick and sometimes the drilling equipment, too, on wheels from one location to another.

You Wouldn't Know Them

General improvement in trucks has been most rapid in recent years. They have a greater variety of engines—of 4, 6, and 8-cylinder gasoline engines, LPG engines and powerful diesel units—increased safety, more comfortable cabs with much greater expanse of glass; and the trucks are more stable on the road.

It wasn't a great many years ago that heaters were practically unknown in trucks. Now there are heaters and defrosters, windshield washers, directional signals, power brakes and power steering. Automatic transmission is available on some trucks but not in great demand as yet in the petroleum industry.

Design and color have put trucks in the glamor class. The wrap-around wind shield and larger glass areas in back and at the sides improve the

By ERNESTINE ADAMS — *Management Editor*

— Ohio Oil.

One of the trucks used in exploration is known as the "marsh buggy." This one searches for oil in Louisiana. Also called "swamp buggies," these vehicles go where it is too dry for boats; too wet for regular trucks.

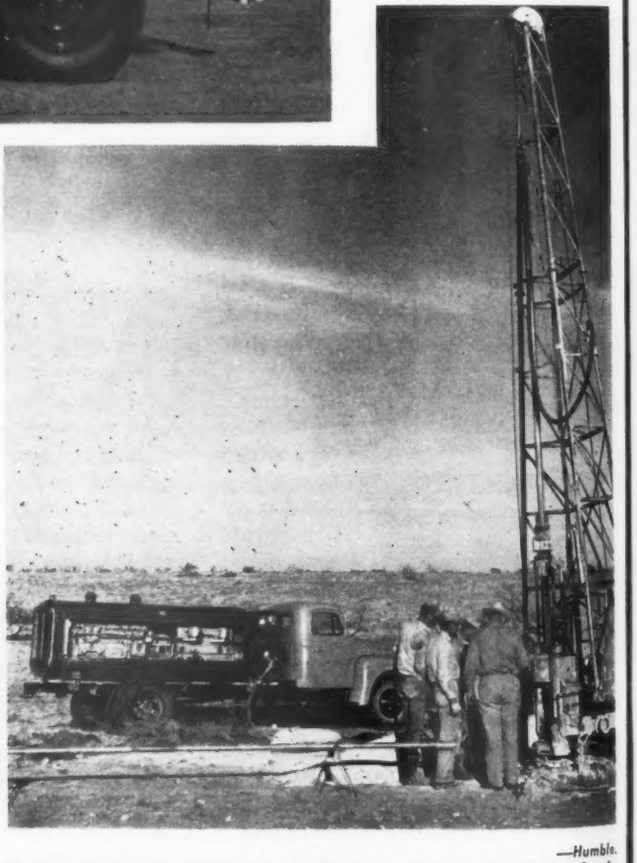
— Cities Service.

The Jeep shown is part of Cities Service's new uranium-prospecting fleet. A scintillometer is mounted in front seat and readings are recorded on a chart geared to one of the wheels.

Conventional shot hole rig equipped with oversize tires for Louisiana operations. Truck is complete with pump, drawworks, mast and small rotary table. Winch is in front on this truck. It can be moved easily over rugged areas.
— Continental Oil.

— Atlantic.

Surveyor's tower rides folded over top of truck and is raised when surveying is underway on rough or brush-covered terrain. Rodman or surveyor can use the tower.



—Humble.

Compressor unit supplies air for drilling seismograph shot holes in West Texas. The truck here is a power unit on wheels. Air-drilling is growing in popularity in some areas.

— Carter Oil.

Interior view of seismic instrument truck. Instruments and truck body were designed and built by Carter.

— Atlantic.

Note front winch on this recorder's truck. Water cans are carried high on fenders. Photo at left gives glimpse of seismic instruments in a similar truck.

driver's visibility and make the cab more attractive. On the whole cabs are lower and steps are lower. Some steps are enclosed by door for weather protection. Adjustable driver's seat adds to comfort and safety. Foam rubber seat cushions and seat backs are available. Sun visors reduce glare and cut eye strain. An instrument panel pad lessens one driving hazard.

Tubeless tires on many models provide greater safety and reduce repairs. Tires are vastly improved in many ways but complete discussion cannot be included in this article.

New trucks provide easier, safer driving and are less expensive to operate and maintain.

A refreshing new feature in looks has been the venture into color. Trucks, like passenger cars, may be almost any color, are sometimes two-tone, and cab interiors may be two or three-tone. Black is available from at least one truck manufacturer on special order only — and few orders are expected, the makers say.

Trucks in the Petroleum Industry

Those early high, narrow trucks with canvas and isenglass protection for rainy days were used for transportation of personnel and materials only. In the petroleum industry today, trucks provide transportation with many other uses. They are mobile derricks, laboratories, machine shops, pulling units, welding shops, mixing machines, fire trucks, painting shops, carpenter shops, etc.

In this industry a truck is not just a truck any more — it is a specialized mobil unit, ready to provide the tools for the job. There is a truck for every purpose — for every step of the whole operation required to provide oil and gas products for the market.

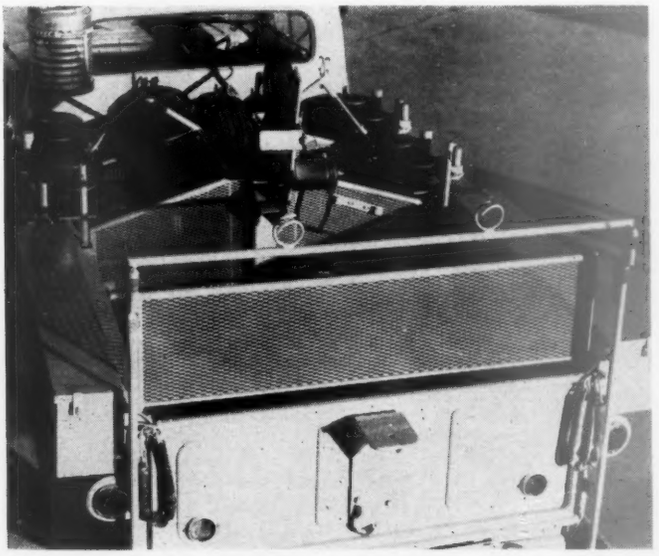
The accompanying photographs show some of the specialized trucks developed by various companies for specific jobs. It has been said that oil truck designers are pretty original and daring. It would seem so.

Exploration Trucks

The exploration team that makes a geological survey usually requires one

— Phillips Petroleum.

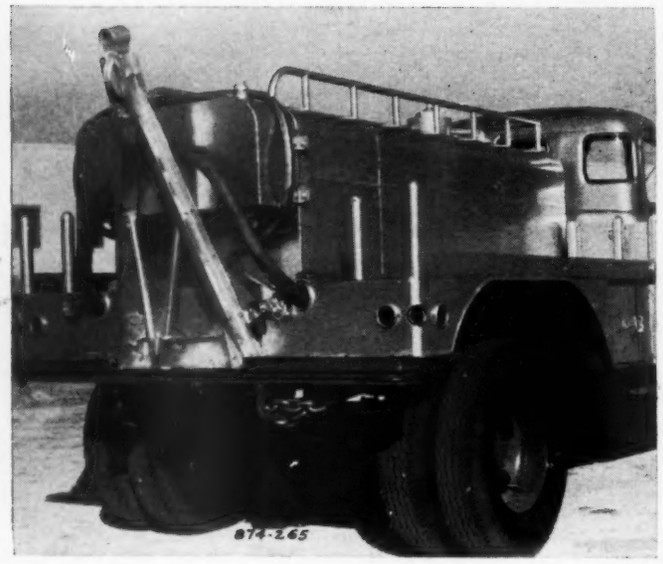
Mounted on rear of this shooter truck is a unique piece of equipment used by Phillips geophysical crews to deflect explosions of debris from seismograph shot holes. This special safety equipment, known unofficially as a "Bazooka," guards personnel from the hazards of shooting near high voltage power lines and protects crops, buildings, etc., from damage caused by blown tamping material. The vehicle also carries supplies and water used in shooting holes.



— Atlantic.

Seismograph truck is equipped with bins and side rollers for laying and retrieving lines. This special truck, designed by Atlantic Refining Company engineers, has two sets of rubber tired wheels on either side. Lines are pressed between tires with firm grip and yet insulation is protected. Tires are driven by electric motors to speed operation of laying lines and pulling them back into bins. Versions of this type of exploration truck have been made by other companies.

XUM



— Atlantic.

Water trucks were once tall and narrow with space on each side of the water tank for carrying other items. Today's water truck is as smooth and efficient as a racer. It has a larger capacity for water in the tank that covers the truck bed, has ample space on top for other freight and gives better view to the driver at back of cab. Water trucks are used in various field operations — exploration, drilling, workovers, etc.

or two small enclosed trucks with four-wheel drive for rough areas.

Sometimes a winch is mounted in front in trucks used for exploration in order to pull the truck through bad spots by fastening the cable to a tree or some stationary object.

A geophysical crew generally has a minimum of five trucks: (1) Crew truck to pick up and transport crew; (2) shooters truck, which carries explosives; (3) water truck, which carries water for drilling shot holes; (4) shot hole rig, a truck-mounted mast and rotary drilling equipment to drill shot holes, and, (5) recording truck enclosed at back to carry instruments on which seismograph records are made.

The seismograph truck shown in photo equipped with bins and side rollers for laying and retrieving lines expedites the shooting operation.

A gravity meter crew usually needs two trucks—a light personnel vehicle and an instrument truck. The gravity meter is generally detachable.

Trucks in Drilling

In drilling the first job may be to build a road to the location and next is to prepare the site and move in equipment. As many as 20 to 30 trucks (some with trailers) will be needed to move in rig and equipment and 10 or 15 will be required for hauling pipe.

As work progresses the service companies come in with their special-built trucks that are mobile workshops and laboratories. Oil well cementing trucks, electric logging trucks, directional survey trucks, etc.

Well completion brings acidizing trucks, perforating trucks, fracturing trucks. A million dollars worth of trucks may be assembled for one job.*

The always indispensible truck for drilling and producing — the one depended on for daily transportation and versatile jobs is the gang truck.

A winch is usually installed back of the cab but sometimes one is built in the front. Then a headache post is set over the winch at the back. Built of stout tubing, the headache post or rack is a protection for the driver when the truck is loaded with machinery. The winch and cable are purchased and installed on the truck but the headache post is designed and built to company specifications so there are a wide varieties of types — even in the same company.

You must add lights, reflectors, fire extinguishers, chains, snatch blocks, a boomer, and other smaller equipment.

When you are all through you have an investment of more than $5000 and you haven't put a tool in one of the tool boxes.

Chassis for many types of specialized trucks may look like this prior to mounting equipment. This one has six-wheel drive by FWD; is powered by a GMC 300-hp diesel engine.

— FWD.

Gang Truck

The most common truck in petroleum field operations is a compact freighter, machine shop, and personnel conveyance. It is built to individual design, and in these days, may be slick and handsome.

First you buy a regular truck — say a 2-ton, with V-8 engine, over-load springs, power brakes, and don't forget

*"Devonian Responds to Super Fracture Job," J. E. Kastrop, *The Petroleum Engineer*, July, 1955. Photo caption page B-29.

— Atlantic.

Modern gang truck in use in Magnolia, Arkansas. Note stout streamlined headache post, winch back of cab, tool boxes on side, back and top. Cab has been remodeled into four-door, five-man cab similar to picture at bottom right.

— Atlantic.

Gang trucks 20 or 25 years ago looked much like this. Benches inside are not very comfortable and protection from weather was questionable.

the windshield washer, heater and defroster. With tax this will probably cost $2200 and up. On the average, gang trucks and other trucks are larger than they were five years ago. One truck buyer said this was because field work requires heavier equipment and also because of refinements added to truck equipment.

Generally the next thing you do — either at your company's machine shop or at a machine shop which specializes in this work — is to have the cab remodeled for 5 or 6 men instead of 2 or 3. The body of the cab is cut through and lengthened enough to install a back seat. The cab will remain a 2-door or can be converted into 3 or 4-door cab. Cost of installing a 5-man cab runs $600 to $800.

Five years ago, you wouldn't have found many crew cabs. Two or three men sat in the regular cab and the others rode in the dog-house type seat

—Union Oil of California.

A versatile truck for field department operations is this GMC with a Crescent hydraulic boom crane in use in the Rosecrans, California, field. Hydraulic A-frame trucks can be used as a light crane to pick up heavy and bulky materials and set them on its own bed. Thus one truck loads, moves and unloads field machinery, engines, etc. Union Oil of California employs seven such trucks, some with five-man cabs for field crews, four-wheel drive for off-highway use.

Modern Chevrolet gang truck with two-door five-man cab. Water cans are carried in front with paper cup dispensers attached to grill. Welding rod has been converted into receiver for used cups to keep them off the lease. Part of headache post is visible. Fire-fighting equipment is fastened to side.

— Sun Oil.

This shows roomy interior of five-man cab on new gang truck. The cab in this case has four doors, a feature that is gaining favor.

— Magnolia Petroleum.

XUM

— Standard of California.

Well-puller shown which looks like a prehistoric animal is strictly functional. The 60-ft derrick, lifted over the cat of the truck, has a gross weight load of 100,000 lb. The whole unit weighs 52,000 lb. The Hopper hoist has a capacity of 7500 ft of 2½-in. tubing.

— Ohio Oil.

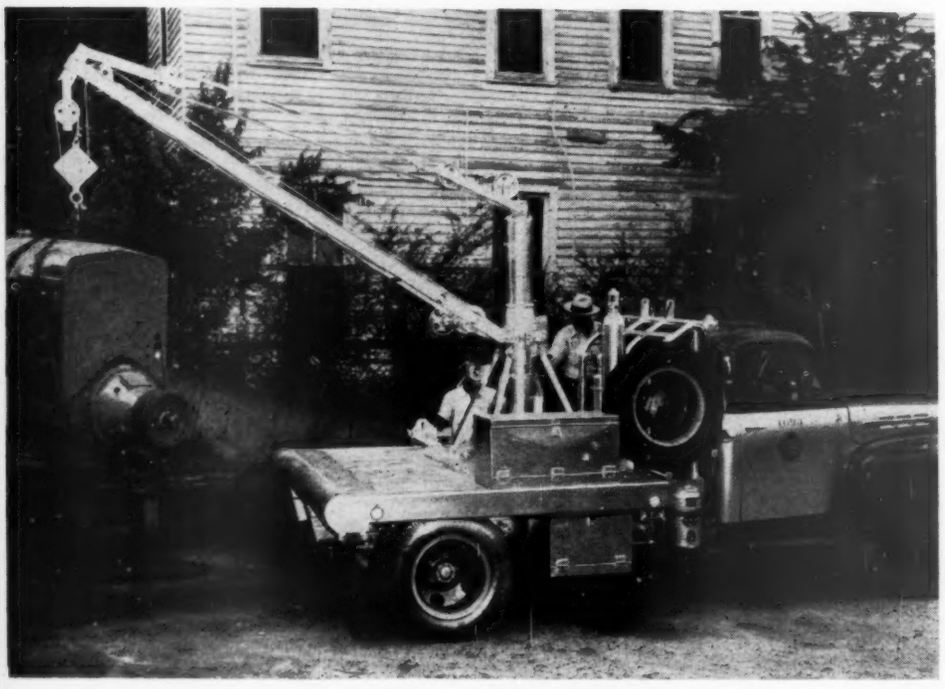
In developing water floods in Illinois fields, this tractor-type International truck backs up under the trailer-mounted cable tool drilling rig and makes fifth wheel connection for a move. A power takeoff winch is mounted directly behind the cab. Cable tools are used for "tailing-in" both input and producing wells after drilling to producing horizon with portable rotaries.

installed back of the cab. There was little protection from weather and dust; springs in the improvised seat were skimpy or non-existent.

In fixing up the gang truck an early addition is the heavy grill in front for extra protection of the engine. These are generally called "brush bumpers." Present brush bumpers are streamlined, and strong, usually extending in front of the regular grill far enough to accommodate a couple of water cans and sometimes an ingenious cup dispenser like the one on the Sun truck shown in the photograph.

Next an extra bed is built on the truck so that tool boxes can be set in between the two beds. These tool boxes open on the sides and at the back—the center one at the back runs almost the full length to take care of long-handled tools.

Derrick arrangement on a flat-bed truck can move engines from pumping well locations to service when they failed in service and replace them with engines in running order.



Trucks in Producing

The gang truck is the central unit in oil and gas production operations. In addition, there are many special trucks designed by company engineers to fit given conditions.

The well pulling unit is one of the necessary rugged trucks. It is used to clean out wells and for workover jobs in the field.

Another special truck is a three-purpose workover truck built as experimental but so successful in field tests that the design is expected to be copied in the future. The combination truck* has all equipment needed for an ailing well. The diesel engine that powers the truck runs the main pump. An auxiliary engine at the rear, powers wire line reels and hydraulic equipment.

There is a cement storage bin and built-in water tanks, which double as cement tanks. Stored in various compartments on the truck are tools, fittings, tubing, blowout preventers and any other equipment needed for workovers.

Other trucks designed for specific jobs are chemical injection trucks, paraffin remover trucks, mechanics trucks, carpenter trucks, and even trucks

*Described in *The Humble Way*, January-February, 1955, page 18.

— *Humble.*

Here is a three-purpose workover truck for well servicing. It is designed to cut workover jobs usually requiring three trucks. Wire line work, cementing and gun-perforating can be handled with this one truck.

— *Stanolind.*

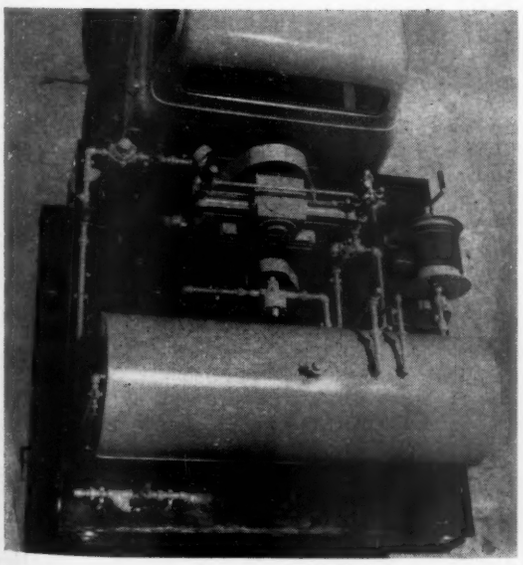
If an oil tank must be moved the Ford gang truck comes to the job. Loaded with the winch, all the big tank goes on the small truck. So simple!

— *Carter Oil.*

Pulling unit mounted on truck is workhorse of the oil field. Used for cleanout and workover, it gets wells back in production in shortest possible time.

— *Sinclair.*

Well pulling unit with single pole mast. Truck has White Super Power chassis. These truck-mounted service units vary considerably as each company designs its own for specific areas and kind of work.



— *Atlantic.*

Chemical injection trucks like the one above are designed for injecting solutions into wells as corrosion inhibitors.

— *Atlantic.*

One of the specialized trucks used in production is the paraffin remover shown above. A wire-line unit and racks for paraffin cutting tools are mounted in the truck bed.

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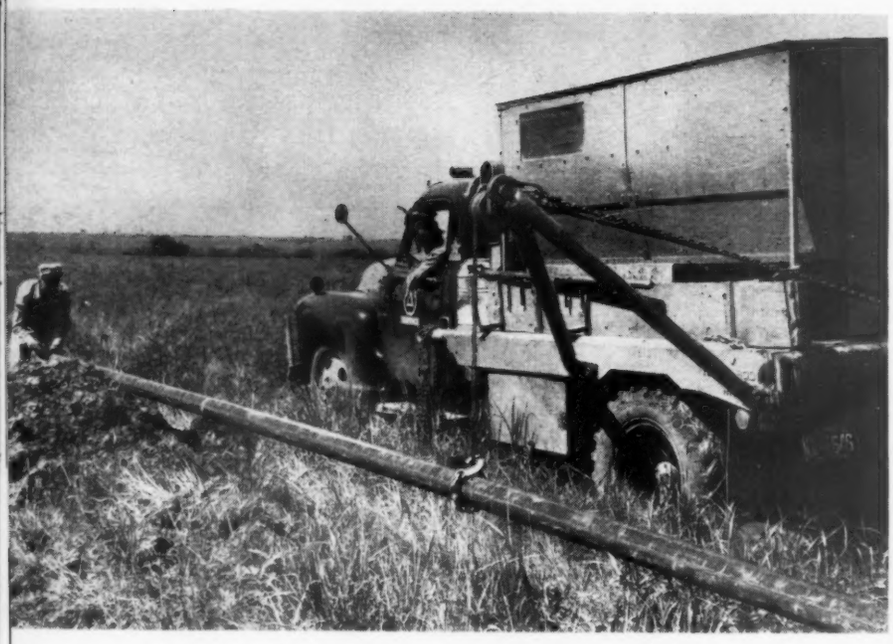


— Cities Service

Gang truck used by pipe line crew in El Dorado, Kansas. The side boom is used in laying and repairing line. Conventional back end boom was impossible because gang cab opens there. Side boom was found to have advantages. Power is from the winch and a block is used to divert power to side boom.

Increasing use of radio telephones in field operations has resulted in improved utilization in truck operations. Driver is shown on pipe line location.

equipped specially for painting in camps, fields, refineries, etc.

One modern design is a truck with a derrick to remove engines that fail from pumping well locations and to replace them with engines in good condition. A job that once required three men and two or three trucks is now done by one well designed unit.

In this truck, power to raise and lower equipment is supplied by truck engine through a power take-off that drives winch on which cable is spooled. Operator stands on left-hand running board to handle controls that operate gears. Steel boxes carry tools and equipment for engines so they can be repaired in field also. This specialized equipment has reduced cost of changing industrial engines on field locations by at least two-thirds, Gulf Oil people say.

Pipe Line Trucks

There has been no attempt here to go into the many trucks used in pipe line construction. That is too large a subject by itself. In some cases it is difficult to draw the line among the trucks, trailers, dozers, etc.

Construction trucks are owned by the contractor and, of course, go from job to job.

Operators of pipe lines, however, keep maintenance crews and do constant repair work by using trucks.

Pipe line welding is done in the field from truck-mounted welding equipment. Notice tool boxes fitted at sides under bed of truck. Similar trucks may carry pipe threaders and pipe benders.

Pipe line crew trucks have made as much progress as field gang trucks. In the pipe line type truck as many as 10 men are transported to location. The truck bed is enclosed and seats arranged opposite each other.

In one such truck recently designed, there are two winches, one at the back of the cab and one in front of the engine. These trucks often travel where there are no highways or roads and the front winch may be used to help the vehicle over rough surfaces.

This truck also has a padded seat on the tool box, a large heater, leather straps like those on a trolley for men to hold on to when moving over rugged terrain, a shelf for traveling bags, two-way radio telephones and a push button for the passengers to ring to reach the driver in the cab. Pipe line crews of a few years ago saw none of these comforts in the trucks they rode.

On top of this particular crew truck is a large sign which can be seen by pipe line airplane spotters. The air reconnaissance can then drop a note to the gang pusher to let him know the next location where repairs are needed.

The welding truck is used in the fields for construction and maintenance of gathering lines and of transmission lines. It has regular arc-welding equipment mounted on truck and storage is provided for tools.

An A-frame truck is needed in pipe line maintenance and repair work. The hoist makes it possible to lift and load pipe to be used to repair a line.

Sometimes a portable pumping unit

is added to this truck group. It is used to pump oil out of a section of pipe before repairs are made or a new section of pipe is tied into the line.

Trucks in Refineries

After construction of a refinery or processing plant, trucks are used for maintenance, turnaround, and, of course, large numbers are used for hauling products.

Maintenance and turnaround require light pick-up trucks, A-frame trucks and crane trucks. Inside work is done mostly by "straddle buggies," rather awkward trucks, which manage to do about any kind of moving needed. The L-shaped hoist swings in any direction. Straddle buggies handle short hauls and eliminate manual or derrick loading.

This brief review could not include the great tank truck industry, which operates a vital part of transportation of bulk liquids. The trend in recent years is to contract this hauling to specialized tank truck companies instead of individual oil companies keeping up its own fleet of trucks.

There are some 18,000 tank trucks,

— Marmon-Herrington.

Used by supervisors and for service this All-Wheel-Drive Ford is shown on a pipeline job in mountainous New Mexico. All-wheel drive makes travel possible when terrain is difficult.

This truck is a conventional A-frame mounted on tail gate. Capacity to move heavy and bulky equipment is one of the great advantages of the modern truck.

Here are two types of boom trucks used in pipeline industry. Structural mast on heavy truck is used principally in construction.

XUM

— Standard of Indiana.

At the Casper, Wyoming, refinery 15 trucks like this one have receiving and sending units for rapid communications.

— Peterbilt.

Filling up at a terminal is a huge tanker truck. The truck has been a vital link in transportation.

both general purpose and pressure units, which move products from refinery to markets, according to National Tank Truck Carriers, Inc. Average capacity is 5300 gal. The "For-Hire" tank truck industry spends more than $150,000,000 a year for new trucks and tanks, motor fuel, and accessories.

Who Buys Trucks

In small oil companies or those of individual ownership, trucks are bought by various management personnel after approval by the top man—either owner or president. For large companies the procedure is more complicated but essentially the same. Orders are initiated at the level where the truck is used. The request is given to the local superintendent and goes through district offices and to division or general headquarters.

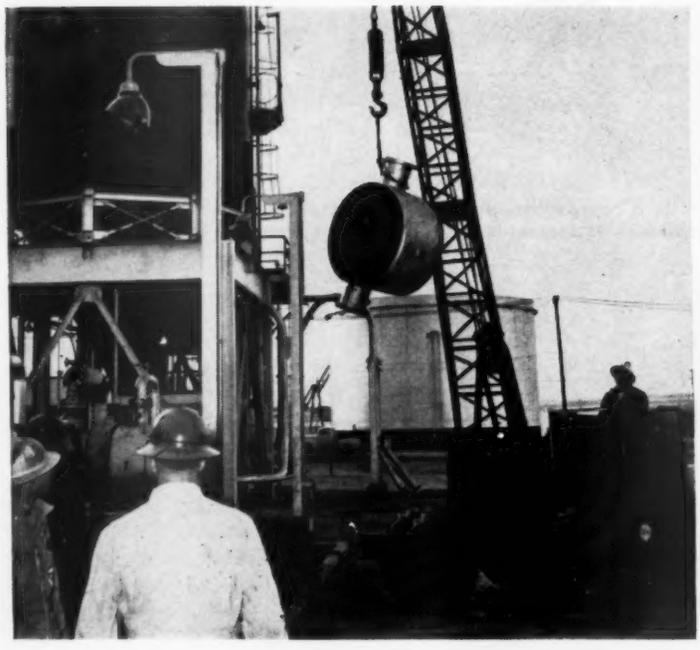
With four or five approvals stamped and initialed on the requisiton it is sent to the purchasing department, which usually buys the kind of truck requested and has it fitted to order.

Some companies maintain regular machine shops where equipment for special trucks are ordered or made and installed on the truck body according to the blue prints drawn by company engineers.

Truck Manufacturers

Largest sales of trucks are made by these manufacturers: Chevrolet, Ford, International, GMC, Dodge, White, Studebaker, Willys truck and Willys Jeep, Reo, Mack, etc. In addition these trucks have played special roles in the petroleum industry: Kenworth, Peterbilt, FWD.

More than half the trucks on the road are five year old or older. It is



— Carter Oil.

Small crane in use at Billings, Montana, refinery when turnaround is made. These trucks with cranes are in constant use in construction and in repair and maintenance in all kinds of processing plants.

— Humble.

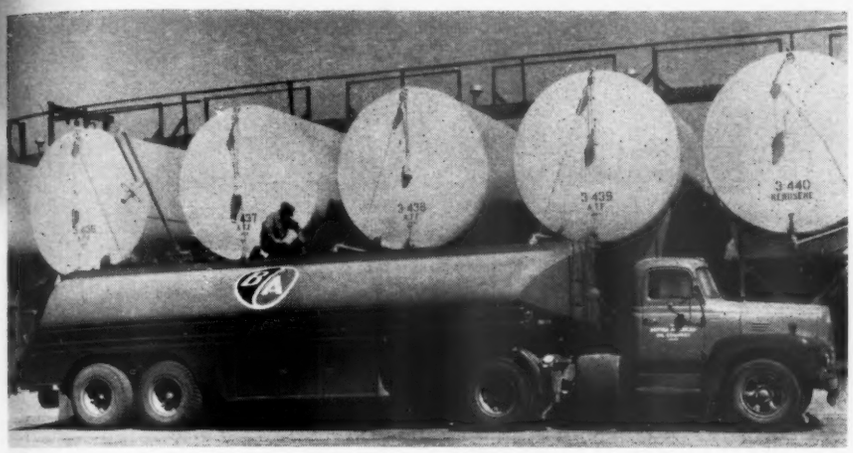
"Straddle buggy" is used inside shops at Baytown, Texas, refinery most frequently to lift and transport pipe, tube bundles and long lengths of timbers.

Fuel oil is delivered to customers at the end of oil operations which begin wth the surveyor. In every step trucks are used. The tank truck below is a gasoline-engine powered Mack truck.

— *Brooklyn Oil Utilties.*

Long sleek tank wagon carries 5250 gal of product and can make prompt delivery. Some tanks are made of aluminum. An International truck pulls the modern new trailer.

— *British-American.*



doubtful if this is true of oil and gas industry trucks. Nearly all automotive equipment in this particular industry are given hard and steady use. A good part of it is off-the-highway use — on improvised roads or none at all.

The United States has by far the largest truck and bus production, manufacturing over a million a year. This is three times as many trucks and busses as are made in the United Kingdom, which is second in production.

Few trucks are imported into the United States—only 426 last year. Exports ran to 179,000 trucks in the same year.

Number in Industry

The number of trucks alone used by petroleum field operations runs into the thousands—probably as high as 100,000 trucks. This does not include truck tractors, tractors, trailers, or passenger cars owned and run by the industry, which together may reach another 100,000 vehicles.

These figures do not begin to tell the whole story. In recent years specialization has divided work into services which are usually contracted for by oil and gas companies.

Geophysical companies, to begin with, are not included in this article.

— *Standard of Indiana.*

A new addition to the fleet of fire trucks at the Standard (Indiana) Whiting refinery. Modern fire-fighting equipment is mounted on Four-Wheel Drive chassis.

Their truck fleets certainly run more than 5000 vehicles at a minimum.

Transportation is gradually being taken over by trucking firms specializing in moving oilfield equipment and oil products. These companies are familiar with state laws and can plan more economic transportation with larger volume.

The 100,000 figure does not include drilling contractors, the companies that do practically all the drilling from California to New York. Nor does it include drilling services—drillstem testing, coring, well logging, cementing, fracturing, perforation—the varied specialized services that travel from drilling site to drilling site by truck.

Construction work in the petroleum industry is almost invariably handled by contractors, which are highly specialized. They build the natural gasoline plants, the refineries, the processing plants, the transmission lines, the compressor stations, the research laboratories and office buildings, the storage terminals, and the service stations.

Cost of Trucks

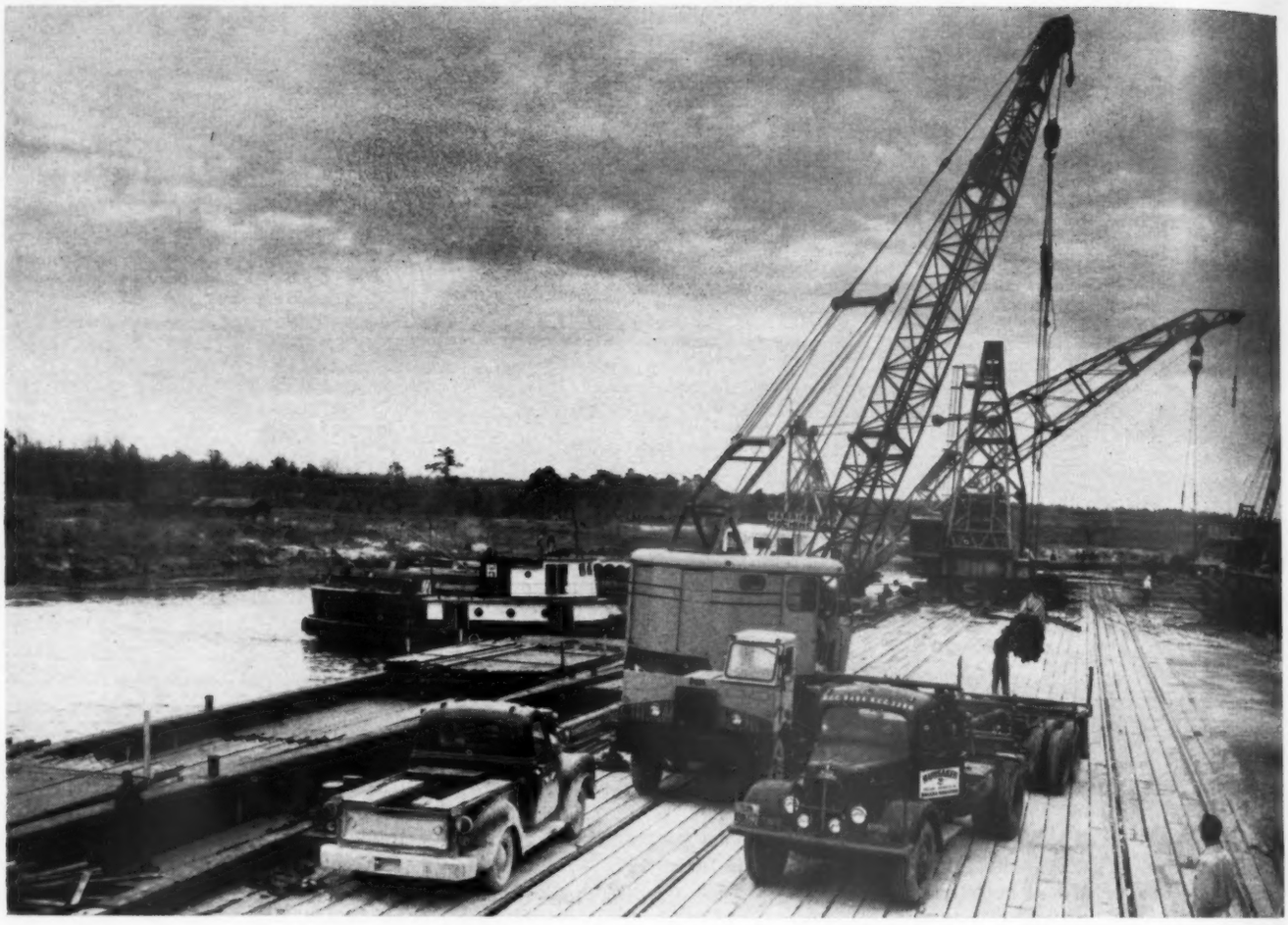
The table gives the general price range of many special trucks used by the petroleum industry. Cost goes all the way from $3000 to $75,000. This price includes chassis, body, and all fixed equipment such as winches, cables, headache rack, tarpaulins, extra power, hoist, drilling rig, shooting equipment, two-way radio, etc.

Because the equipment may vary greatly in the same type truck, the range in one category can be very wide.

The truck is usually especially designed for a particular purpose and every company has its own objectives. It would be hard to find more specialized trucks than those built for the petroleum industry and its supply and servicing industry.

Costs of servicing company trucks have not been included but it is known that they are major investments, often running above $100,000 fully equipped.

These valuable trucks are power plants, compressor plants, machine shops, welding shops, laboratories, etc.,



— Magnolia.

Scene at Greensboro, near Houston where truck contractors are unloading pipe from barges and will truck them to company warehouse for field supply. One of the recent trends is that more contract hauling is done in the petroleum industry.

Costs of Petroleum Industry Trucks, Including Equipment

Shooters truck	$ 6,000 to	$ 7,000
Shot hole drilling unit	9,000	16,000
Recorder truck	30,000	50,000
Gang truck	3,200	7,000
Pipeline gang truck	5,000	8,000
Boom truck	3,800	7,000
A-frame truck	4,000	12,000
Water truck	9,000	11,000
Heavy material truck	15,000	20,000
Well servicing truck	25,000	60,000
Well pulling unit	25,000	75,000
Fire truck	22,000	29,000
Straddle truck	15,000	22,000
Tank truck	8,000	21,000
Truck and trailer tank vehicle	30,000	35,000

which bring service and supplies to the well site. Large expenditures for these trucks are economic because of the very mobility that permits an extensive area to be covered by one unit.

The table at left shows the lowest and highest figures given by oil companies as the cost of different types of trucks they have purchased. Only trucks owned by petroleum firms are included.

Trends

It was not easy to find agreement among users on future trends in trucks. Most operators think the modern truck with available equipment is at a peak in appearance and performance. Truck manufacturers say—"Wait until you see the 1956 models now on the way."

Only one thing drew any recognizable agreement—that trucks were getting bigger.

"Where I once ordered a two-ton truck for hauling, now the men in the field want four and six-ton models," said one automotive manager of an oil company.

Others mentioned that trucks had to be larger for deeper drilling, bigger pipe lines, faster distribution needs.

"Big trucks are more economic in our business," said a purchasing head. "Increase in trucking load limits have been made in several states and as these go up so will the size of trucks."

One buyer thought four and six-wheel drive had gained greater acceptance in recent years. These trucks are specially adapted to rough terrain and the rugged parts of the country, like the Rocky Mountain region, have seen more activity since World War II.

Another trend is found not so much in trucks as in truck ownership. The number of trucking companies specializing in oilfield work has grown considerably in the last few years and older companies have expanded. Like drilling operations, pipeline construction, well servicing, etc., the industry finds it more convenient to contract for transport by truck in circumstances where oil and gas companies formerly did their own hauling.

For the petroleum industry the greatest trend is the lesson already learned — that almost any equipment used in oil operations can be used more efficiently and more economically if it is on wheels. Truck-mounted machinery expedites operations in every branch of the industry. * * *

Exploration, Drilling, Producing

Idaho Gets First Gasser

Idaho's first successful well has been finaled by Oroco Oil and Gas of Ontario, Oregon. The well, the No. 1 Johnson, is located in Payette County on the Idaho-Oregon border. Completed as a gasser with a reported flow of 400,000 cu ft per day from an interval at 1379-422 ft, the discovery is nearly 800 miles from a point of distribution for service and supply. At present there is no established outlet for production, although construction of the Pacific Northwest pipe line is considered a market possibility. Oroco has spudded a second test several miles south in the Fruitland area, and is awaiting testing tools on another well in the Payette area.

★ ★ ★

Guatamala Revamps Laws

Recently adopted Guatamalan legislation designed to enable and attract exploration by foreign oil companies has been met with little favor by U. S. groups. The laws would provide that 50 per cent of all net income from oil exports or a 12½ per cent royalty in oil be paid. Three types of permits are being offered by the government. One would allow only surface exploration, the second would permit test drilling, and the third would give approval for actual exploitation and export of oil, although such permit would limit operations to about 62,500 acres.

★ ★ ★

Falcon Seaboard Safety

Rigging up and tearing down produce the majority of lost-time accidents, Falcon Seaboard Drilling Company reports. The company, which operates 27 rigs, indicates that it may experience its safest year. One of the rigs running near Elkhart, Kansas, has been accident-free since November, 1953. Thirteen have operated without a lost-time accident during the first six months of this year; nine others have operated with only one disabling injury.

★ ★ ★

Shell Is Top Bidder

Shell Oil Company paid $5,423,760 to the government in exchange for 18 offshore tracts acquired in the last lease sale. Shell received leases on 103,680 acres in the High Island area off the coast of Texas, varying in price from $17.50 to $177 per acre. Humble Oil & Refining Company was high bidder on four tracts in the Galveston area paying $2,321,481 for 23,040 acres. Prices on two of Humble's tracts averaged $158.01; on the other two, the average was $58.01. A combine made up of Pure, Ohio, Sun, and Seaboard oil companies paid $592,220 for four tracts in the High Island area. All tracts are located beyond the state-claimed 10½-mile limit.

★ ★ ★

Conoco Combines Divisions

Continental Oil Company has consolidated its Corpus Christi and San Antonio exploration divisions into one, with headquarters at Corpus Christi and has transferred the company's Texas-Gulf Coast production office from San Antonio to Corpus Christi. The announcement followed establishment of a new Conoco district marketing office. The latest expansion program marks the addition of approximately 25 persons to its staff at that location in the last four months. The division exploration office will supervise exploration activities throughout South Texas.

Amurex Buys Ponder

Agreement has been reached for the acquistion by Amurex Oil Company of Ponder Oils Ltd., including all capital stock of its subsidiaries, Ponder Oils, Inc. and Devon Drilling Company, Ltd. Ponder has oil production in Alberta, Manitoba, Montana, and West Texas.

★ ★ ★

SEG Slates Sessions

Society of Exploration Geophysicists are expecting nearly 2000 at its twenty-fifth anniversary national meeting in Denver, Colorado this fall. The group, meeting October 3-6, will for the first time meet independently of the AAPG and Society of Exploration Paleontologists and Mineralogists. Sessions slated at the Shirley Savoy Hotel will focus on mineral exploration, and will highlight operations and safety, studies of seismic wave generation by explosives, geophysical techniques and interpretation. Other subjects include electrical logging, geological and geophysical case histories of oil fields.

Louisiana Gulf Coast Oil Exposition progress and plans are being discussed by John Prejean, manager of Prudhomme Oil Company, and Roderick Miller, attorney (standing); Wilbert Woody, show general manager, and Mrs. Gloria Knox, Sinclair "landman." The show is to be held October 13-16 in Lafayette where more than 200 exhibitors are expected.

It takes all three

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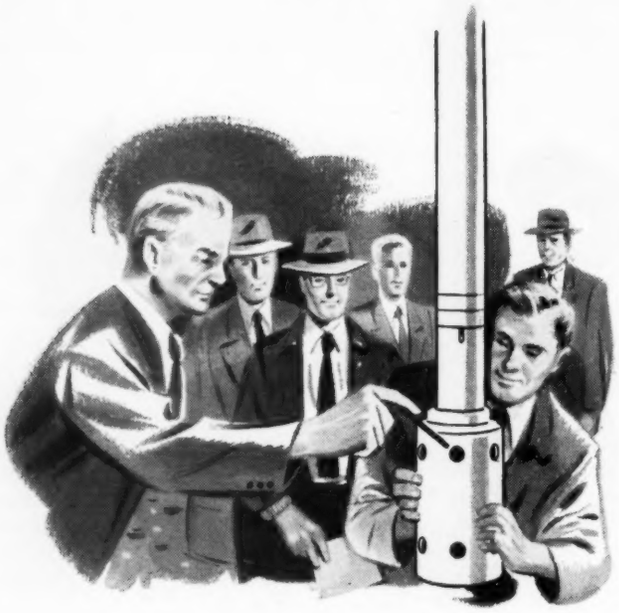

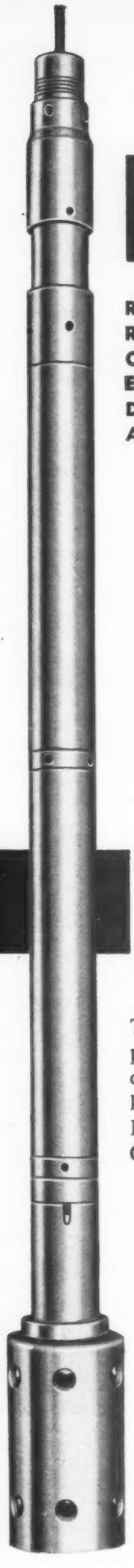

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XUM

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New techniques, ideas, and better transportation are a great aid to the geologist, but his job is even bigger today than ever before.

Photo courtesy Magnolia Petroleum Company.

The Geologists' Challenge In Exploration Today

Graham B. Moody

THE term "geologist," as referred to here, includes geophysicists, macro-paleontologists, micro-paleontologists, electric log experts, and all others engaged in the search for petroleum by technical methods. We are all looking for oil; we are all "oil-finders." The earlier search for oil was prosecuted, of course, by geologists, in the limited meaning of that term, before geophysicists and micro-paleontologists could lend a helping hand. No distinction is made between the geologist by strict definition, the geophysicist, or the paleontologist in regard to the importance of any one of them in the exploratory picture. It is much easier, however, to write "geologist" than to list each kind of scientist every time reference must be made to one engaged in exploration.

The continuing rise in demand for crude oil throughout the world and the increasing difficulty experienced in finding large fields in the United States, which has furnished 60 per cent of the world's production to date, presents a stimulating challenge to the geologist. This challenge actually is nothing new to this group, which has been meeting successfully a somewhat equal challenge ever since the first pessimistic expert on future crude supply prophesied the early exhaustion of our crude oil supplies. That was many decades ago. It is true that the problem becomes more intriguing, and perhaps more complex, as demand increases by leaps and bounds, as the size of individual discoveries decreases, as the cost of finding each barrel of oil mounts, and as each discovery reduces the number of fields and pools remaining to be discovered.

The geologist's accomplishments have been limited at any specific time by the exploratory tools at hand, volume of data available for analysis, generally accepted geological concepts, and his own imagination. Development of each new exploratory tool and the introduction of each new geological concept related to the origin and occurrence of petroleum broadened his outlook and increased his efficiency. His imagination or, if you prefer, his ability to formulate a new idea from old data became more acute as he critically analyzed theories and results of exploration over the years.

Numerous aspects of exploratory effort have undergone extensive modification during the first half of this century. These may be classified as the physical conditions of exploration, exploratory tools, geological concepts, and economics. They will be discussed in following paragraphs but may be summarized by the statement that the algebraic sum of all changes shows a decided balance in favor of continued success of our exploratory effort.

Physical Conditions of Exploration

The pioneer geologist worked under field conditions that might seem decidedly undesirable to a modern geologist. He camped out for long periods

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Highly specialized and mobile field equipment speeds up the search and increases the accuracy of our knowledge of the earth.

Early efforts to look for potential petroleum provinces were hampered by transportation facilities and lack of roads, as illustrated above.

of time; he lived with his work. He could, and did, shoe his horses and sole his own boots. He kept his camp stocked with food for both man and beast. He was prepared to "doctor" his men and horses when they were ailing. He needed a lot of know-how and still more endurance to carry on his geological investigations and to keep his outfit running smoothly. He was, fortunately, totally ignorant concerning the 40-hour week; this enabled him to accomplish quite a bit in the field and may, perhaps, explain how he contributed so much to the science of geology and to the world's petroleum reserves.

Advent of the automobile increased, at times, the speed of travel but piled further responsibility onto the geologist. The auto did not function smoothly always, if ever, and garages were scarce and far between; many garage mechanics were converted blacksmiths and treated automobiles accordingly. The geologist became from necessity a fairly good mechanic. He carried all kinds of spare parts for the car: wheels, axles, valves, bolts, nuts, tire-repair kit, plenty of bailing wire, and extra cans of gasoline and oil. It must be admitted that the early automobile added spice and excitement to the geologist's life in the field, but it used up a considerable part of his energy that might have been employed in searching for oil.

Other forms of transportation moved at a snail's pace in comparison with modern speeds. It often took several days by train to reach the starting point for a geological investigation in the United States. A foreign trip might involve several weeks aboard ship in order to reach the take-off spot. The old sedate modes of travel, however, had one enormous advantage over present rates of travel — the former gave the geologist some time to relax and to think.

It should be commented that geologists in some localities still encounter extremely rough going and are just as rugged as were their predecessors. By and large, however, the physical conditions under which exploration is carried on now are more pleasant than in the early days. It takes only a short time now to travel from here to anywhere. Automobiles are both luxurious and efficient, and filling stations and garages are scattered profusely across the landscape in the U. S. and in many other countries. Much exploratory work can be carried on with headquarters in a comfortable hotel or motel, where excellent, if expensive, food is available. Oil companies are providing everything possible for the comfort and safety of their exploratory men. Long experience has shown the companies how to provide facilities that make living and working much easier for the geologist now than heretofore, even under the most rigorous conditions of the frozen north, the steaming tropics, or the parching desert.

The great speed-up in transportation and the general improvement in physical conditions under which exploration is conducted have expanded the geographical limits of a geologist's activities and given him more time to concentrate on his primary job — finding oil. These considerations should be entered on the balance sheet in favor of continued success in exploration.

Exploratory Tools

Some geologists can remember the time when a kit of exploratory tools consisted of a topographic map, pick, Brunton compass, aneroid barometer, hand-lens, pace-counter for measuring "accurate" distances, camera, sample bags, bottle of acid, and sometimes a plane-table and allidade. These simple tools were quite efficient when the geologist was studying surface structures and the lithology and macrofaunal content of rocks were exposed on the surface. In fact, these same tools are still mighty useful and are employed in some regions. There was comparatively little subsurface information available in the early days; few wells had been drilled, and the logs of these were often more confusing than illuminating.

Aerial maps, micro-paleontology, geophysics, electric and other types of logs, and core analysis rapidly furnished the geologist with valuable means for correlating his surface observations with subsurface conditions. Some of these were new branches of science adapted to the needs of exploration. Thousands of wells were drilled, and they furnished data of great value, whether they were dry holes or producers. Drilling technique and equipment was vastly improved so that holes were carried progressively deeper, thus opening up new provinces to geological analysis.

These new tools and the vast amount of information disclosed by wells drilled are of great assistance to the geologist. It is true, however, that the development of new methods of exploration has opened the era of specialists. No one man can be a master of all of exploration's aspects. Someone must weave the threads of information supplied by the various specialists into

a complete mosaic that indicates the probability of finding petroleum in a specific locality. The geologist (using this term in its limited meaning for this one case) is best qualified to correlate the findings of the numerous experts in the different special branches of science affecting exploration for oil.

No entirely new method of exploration for oil can be foreseen at present. It might be an ideal situation to develop a method that would indicate definitely whether or not petroleum were present at a given location and, to stretch the imagination to the limit, at what depth. Such a possibility is not in sight, fortunately, because it would take all the fun out of exploration and would flood the market with surplus crude.

Old exploratory tools will be sharpened and adapted to meet specific problems of the future. Much remains to be done in re-appraising seismograph records, core analyses, and electric logs. There are literally tons of records lying dormant in files. Critical study of these in the light of experience since the records were buried should lead to the discovery of new oil provinces.

Geological Concepts

The anticlinal theory ushered in the technical search for petroleum. Efforts were limited at first to finding exposed anticlines. Even after the relation of physiographic features to subsurface structure was recognized and paleontology and geophysics added immeasurably to information on subsurface conditions, the primary goal of the geologist was to find an anticline, which was considered to be the ideal trap for petroleum.

The first major revolution in geological thinking about traps to collect petroleum happened when A. I. Levorsen explained the significance of stratigraphic traps. Geologists grasped this new exploratory concept enthusiastically and have been using it with success ever since. Geophyiscal methods do not locate these stratigraphic traps, which must be found by studies of local and regional distribution of sediments.

The most recent concept is related to the flow of fluids through reservoir rocks. Petroleum engineers investigated this phenomenon originally. One aspect of fluid flow solves the earlier mystery of oil pools located on the flank of structures with water at the crest. M. K. Hubbert has been largely responsible for demonstrating the mechanics that produced displaced oil deposits and tilted water tables in oil pools. The geologist can re-examine now the records of dry holes drilled on attractive structures and evaluate the probability of finding oil at less favorable structural locations, basing his conclusions on this new concept.

Economics

Much has been said and written on the increased cost of finding oil. It is entirely in order that the gross cost of discovering new reserves should rise. The price of all commodities has gone up prodigiously. Materials and labor cannot increase in value without increasing the gross cost of finding oil. When one couples the general elevation in costs with the fact that several specialists are needed on each exploratory team and that many new and expensive methods of testing formations encountered in a well are employed, it is not surprising to conclude that the cost of finding oil mounts continuously. The important aspects of the problem are concerned with the unit cost of finding oil and our ability to discover sufficient reserves to meet increasing demand.

It has been said that the average cost of finding a barrel of oil has quadrupled since before the last world war. The writer has seen some rather astronomical numbers about discovery costs but was pleased to note that exploratory costs of something over $1.80 for each barrel found during 1953 had been reduced to around $1.50 a barrel in 1954. This is still an extremely high figure and suggests that the average explorer for oil is on the verge of becoming bankrupt. Under such circumstances, it seems surprising that so many large and small companies and so many independent producers continue the search for new supplies of petroleum.

Many of the analyses of exploratory costs are based on the estimates of new reserves discovered annually, as published by the American Petroleum Institute. These estimates of the API are excellent and represent the new reserves actually proved by discovery during any year. The analysts take off on their calculations from these basic numbers, adding to them a certain percentage of the reserves contributed each year by extensions and revisions (again from API estimates) and arriving at an adjusted number representing the total barrels added by discovery. This figure is then divided into total exploratory expenditures derived from oil companies' annual reports; the answer is the cost per barrel of finding oil.

The writer might not quarrel with this method of analysis provided that the analyst knew what percentage of the reserves credited to extension and revision in any year belonged to the fields and pools discovered that year. It is impossible to estimate at the end of a discovery-year the ultimate recovery of the really large fields and pools discovered during that year. Many of our most prolific fields were estimated originally to have comparatively modest ultimate recoveries; extensions and revisions in the next few years expanded the estimates of these fields manyfold above the first estimates. It is a hazardous undertaking to apportion reserves added by extension and revision to the actual discoveries made in any particular year.

Another factor influencing ultimate recovery may be overlooked in estimating costs of discovery. Petroleum engineers and other operating men are continually improving methods of recovering oil so that ultimate recoveries rise beyond previous expectancy. These increases, of course, appear as revisions in earlier estimates; the time at which the revisions are made must be related to the years when the fields were discovered in order to determine how much oil was found in those years.

The true value of a barrel of crude is not measured accurately by the posted price. The value of associated natural gas and natural gas liquids should be added to the posted price of the crude in order to obtain its total value. Improved manufacturing techniques, furthermore, have derived new products from crude, thus increasing the actual worth of a barrel of crude today as compared to its value some years ago. These considerations must be taken into account when comparing the cost of finding a barrel of crude with the ultimate worth of it.

Perhaps the most realistic approach

The Author

Graham B. Moody is a veteran field geologist whose assignments with the Standard Oil Company of California have taken him to the Philippines, Mexico, and a portion of the southwestern United States. He retired December 1 and now is engaged as a petroleum consultant. He served as chief reserves engineer on Standard's executive staff.

Moody, who completed his 34th year with Standard of California in 1954, was graduated from the University of California. In 1917 he joined the Southern Pacific Company as resident geologist. The following year he moved to the California Petroleum Corporation and was associated with that firm until 1920.

Active in petroleum industry professional circles, Moody is affiliated with the following organizations: American Association of Petroleum Geologists, American Petroleum Institute, American Gas Association, Seismological Society of America, and Petroleum Production Pioneers.

to determining how much oil has been found over a period of years is to compare the reserves at the beginning and end of a given period and the production during that interval. Crude oil reserves of the United States at the end of 1954 were estimated to be 29.6 billion barrels according to the American Petroleum Institute. The analogous figure for the end of 1945 was 19.9 billion barrels. Production during the period was 18.4 billion barrels. The increase in reserves of 9.7 billion barrels plus the production of 18.4 billion barrels gives a total of 28.1 billion barrels of reserves added during the nine-year period. It is true that some of this additional oil was from extension and revision of estimates for fields discovered before the end of 1945, but a large proportion of the entire amount should be credited to new discoveries made during the period. Discovery of new fields and new pools during that nine years, however, added only 4.6 billion barrels of oil, according to the published figures of the API. The 4.6 billion figure represents the amount of oil that was proved at the end of discovery-years and was not intended to represent the probable ultimate recovery of the discoveries. It seems quite probable that final estimates of ultimate recovery for discoveries during that period will exceed the 18.4 billion barrels produced.

Mental Attitudes

One of the geologists' big problems in early days was to persuade operating and managerial personnel that his opinion was of value and that his recommendations were founded on something better than mere guessing. It required many years for the geologist to emerge from the level of a tolerated nuisance to that of an essential and respected member of the oil family. He gained this change in status largely through supreme confidence in his own ability, which led to his notable achievements that simply could not be disregarded by management.

Physical conditions of exploration may improve, new exploratory tools may be developed, but the mental attitude of the geologist must never change. He is an optimist, sure of his own ability, courageous in his recommendations, confident that his exploratory ventures are better than average risks. It is more important than ever before that the geologist should have implicit faith in his conclusions so that he can make his recommendation to management without qualification. To paraphrase an old saying: Too many qualifications spoil the recommendation. The writer, of course, refers to judicious optimism in the geologist, the type of optimist who has weighed all of the pros and cons of a problem before becoming optimistic about its final outcome.

There are a number of mental attitudes that hamper a geologist from reaching a balanced conclusion concerning the possibilities of an area. Among these are prejudice against some formation or against an entire geological province, acceptance of another's opinion on an area, placing an inflated importance on the number of dry holes in an area, desire to be 100 per cent correct in recommendations, failure to milk the last drop of pertinent data from the mass of non-important information, and finally, lack of imagination.

Old Prejudices Refuted

Every reader can recall numerous instances of formations or even entire geological provinces that have been written off for years as "impossible" repositories of oil in commercial quantities. Prejudice against a formation or province may date back many years to an opinion expressed by a geologist who made a qualified statement, based on data and ideas then available, that the formation or province in question gave little promise of having collections of oil in commercial quantities. Perhaps the statement was as nearly correct as any that could be made under limitations of the time. Many years are required before such published conclusions are refuted by the drilling of a producer in the "condemned" formation or province. A rather recent example of such delay in time of discovery is Cuyama Valley with its two large fields.

Acceptance of prejudices and of the opinions of others constitutes a thought-barrier to the geologist. He breaks through such a thought-barrier by rejecting all prejudices and questioning the authenticity of the conclusions of other geologists.

It is obvious that a good oil field may be ensconced amidst a galaxy of dry holes; this fact has been overlooked many times, thus delaying the discovery of the field. A thorough study of logs of dry holes could have pointed directly to the location of the oil pool long before some inquisitive geologist retrieved the logs and recommended drilling the first producer.

We all like to be right at all times. The geologist cannot hope to bat 1000 on his recommendations to drill exploratory holes. This should not deter him from a favorable recommendation if that course is indicated after weighing all data. The only way to get oil in the tank is to drill for it. The more wells that a geologist causes to be drilled on his considered recommendations, the higher will be his batting average.

Many Acres Still Unscratched

Discovery of reserves has tended in the past to go by cycles. A period of many good discoveries was followed by a period of few and poor discoveries. These cycles were caused in part by introduction of new techniques in exploration, each one of which rapidly found the cream of fields and pools amenable to discovery by that particular technique. When the cream had been skimmed, there followed a period of low discovery (skim-milk) until a new technique or concept brought another upward spiral of discovery.

All techniques and concepts that have found such enormous volumes of oil in the past are now available to the geologist at a single time—the present. There are still remaining, even in the United States, vast areas not yet condemned by drilling. When all possibly petroliferous provinces in the U. S. have been punctured by exploratory holes to the density of the Los Angeles Basin (about one well to each square mile of sedimentary area), it will be in order to worry about future sources of petroleum. The Great Plains region has scarcely been scratched. Nevada, Oregon, and Washington are beginning to be explored systematically. There are other likely regions also. Some of them have been explored rather extensively in the shallower zones, but large volumes of sediments remain to be tested at greater depths. This is particularly true where thrust faults with considerable displacement occur.

When the geologist has exhausted the exploratory possibilities of the United States (that is a long way in the future), he can turn more of his attention to foreign exploration, to which he has lent most efficient aid in the past. It is the writer's opinion that the geologist, armed with all of his present tools and concepts, can and will meet exploration's challenge successfully. The dire prophesy of 1925 that the U. S. would be almost entirely dependent on foreign countries for its supply of petroleum by 1950, and the other one in 1920 that petroleum reserves of the United States, if produced at the rate then prevalent, would be used up by 1940, seem ridiculous in the light of production since those dates and our knowledge of current reserves. If any forecaster should issue a similar statement now concerning the future of our reserves, it would not be too astonishing. We have been rapidly running out of oil for many tens of years, according to some seers. The only difficulty has been that geologists have gone about their business of discovering oil in sufficient quantities to meet demand with a surplus remaining. The writer is confident that they will continue to do so for many years in the future. * *

U.S. Geophysical Activity Starts Upward Push

Record Domestic Demand May Be Big Influencing Factor

J. E. Kastrop,
Editor, Exploration, Drilling and Producing

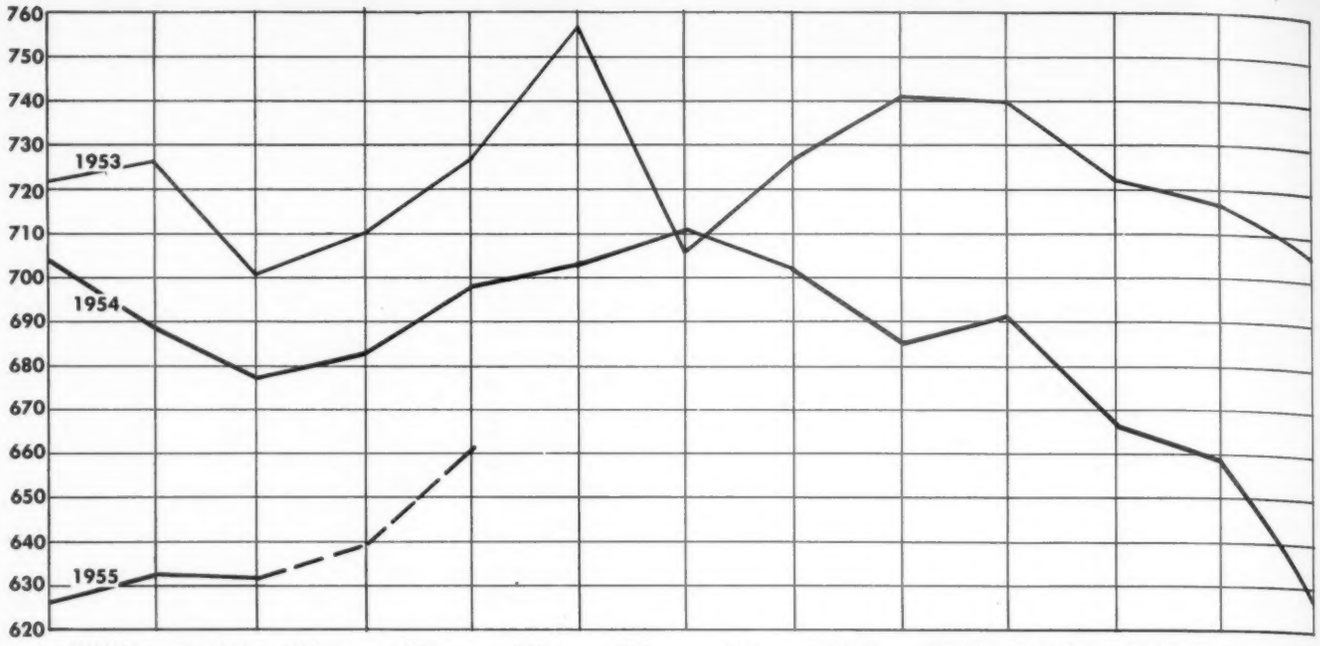
FOR the first time in nearly a year, geophysical activity in the U. S. is on an upward swing after nine months of a continuous downward trend. The geophysical industry is the first to hail the coming of more work. It's been a long "drought," and the slacking of work for these highly specialized crews has taken its toll in shifting of technical manpower into other electronic fields as well as imposing an economic strain on geophysical contractors. The number of geophysical crews, including seismograph, gravity meter, and magnetometer, active at any one month in the U. S. reached a low of only 626 total crews at the end of December in 1954 since the all-time high in the fall of 1952, when nearly 800 total crews were active.

Fig. 1 summarizes the activity for all types of geophysical surveying in the U. S. since January 1, 1953. At this writing, final reports for those months following April 30, 1955, were not available, so this year's activity is indicated only up to that time. While the totals for all states in the U. S. were not complete for the months of March and April, reports were complete from those states where activity was the greatest. It is encouraging to note that, based on these reports plus estimates of those few states not yet reported (and which normally have relatively little geophysical activity), overall geophysical activity is definitely on the upswing. After reaching a nine-month low of 626 total crews in December, 1954, activity has climbed to a total of 662 crews at the end of April this year. While far below what it should be in view of the enormous drilling program set for 1955 and the accelerated demand for U. S. crude as indicated by the first six months, it is an encouraging indication to the geophysical industry, the very life and blood of which depend upon continued activity on a high level. It is true that geophysical activity statistically leads actual drilling by about three to five years. That is, this is the average time normally required to make the survey, analyze results, process the leases, make further regional studies, obtain drilling blocks or agreements, stake the location, and make drilling arrangements.

What Caused It? An analysis of why geophysical activity has slumped in the U. S. during the past two years is difficult to account for, other than to put the accusing finger on general economics of the oil industry in this period. After an extremely bright year in 1952 when demand exceeded anyone's prognostication, use of petroleum products in the U. S. began to lessen in 1953 and was somewhat disappointing last year. This is not to imply that demand in the past two years was less than it was in 1952. The fact remains that the percentage increase in demand was not what economists had predicted. Since the end of World War II, demand for U. S. crude has increased at the rate of about four per cent annually. Last year, it was below this figure.

Another factor which might have some influence upon this downward trend in geophysical activity is the overall cost of finding a new barrel of oil. There is no dispute that the cost of finding new supplies of petroleum has gone up appreciably. There was a time when the national average was about 75 cents per barrel of new oil discovered. In 1953, this estimate rose to about $1.80 per barrel, a discouraging fact when viewed from oil industry management's position. Preliminary figures indicate that this cost to find a barrel of new oil has come down in 1954 to about $1.50, an encouraging fact indeed. Since petroleum reserves are the stock of any oil company or operator, it is essential to maintain these reserves at a high level in order to remain stable in the years to come. No company, however, can afford to pay a high price for oil in the ground and sell it at the "break-even" point or lose money in the transaction. For this reason, it is important to keep the cost of finding a new barrel of oil down as long as the selling price of crude remains at what it is today. Should this cost of finding new oil go too high, there are two alternatives: (1) Increase the selling price of crude in the field, or (2) look to cheap foreign oil. The industry as a whole would not be in favor of either course of action. Therefore, this lowering in the cost of finding new oil might be an influencing factor in the overall increase in geophysical activity.

Not to be slighted whatsoever is the



—Data courtesy the Interstate Oil Compact Commission, Oklahoma City.

FIG. 1. Geophysical activity for the U.S. since January, 1953. Figures are totals and include seismic, gravity meter and magnetometer crews. Estimates for March and April, 1955, are based on reported increases in Texas and Louisiana.

unprecedented increase so far this year in demand for crude domestically. If this factor is related to the downward trend in geophysical activity, then it logically should have some influence in the upward turning trend. It is interesting to note that this nation's thirst for petroleum has exceeded all predictions for the first six months this year. At the outset of 1955, the experts predicted an increase over 1954 of from three and one-half to five per cent. Now after a record demand period, even these high predictions are being revised upward. If demand continues throughout the remainder of 1955 as it has for the first half, this increase will probably reach six per cent and possibly more over last year's consumption, according to the experts. U. S. Bureau of Mines' figures for domestic production since 1952 are as follows: For 1952, 2.7 billion barrels; 1953, 2.8 billion; 1954, 2.8 billion barrels, and it appears the total U. S. demand for this year may exceed 3.0 billion barrels. This trend began developing in the fall of 1954, and it could have played an important role in the awakening of geophysical activity that started on the upswing in the U. S. in March of this year.

Areas of Influence. Greatest influence in this increase in geophysical activity came from Texas and Louisiana, principally South Louisiana. In February, 1955, there was a reported 209 total of crews of all types at work in Texas. Reports for April show a total of 230 crews. In Louisiana, there was a total of 116 crews active at the end of last January, with about 90 per cent of this total located in South Louisiana. In May of this year, this total rose to 147 crews broken down as follows: One hundred twenty-five seismograph (only 14 were located in North Louisiana); 22 gravity meter crews, all in South Louisiana, and no magnetometer crews. There were slight changes in other states, principally in the Rocky Mountain area, but the remainder were not significant changes to effect the overall picture to any discernible degree.

The Louisiana Picture. The announced sale of Louisiana offshore leases by the U. S. Government at the beginning of this year accounted for some stepped-up activity in the Gulf of Mexico. It is important to note that this stepped-up activity by these relatively few operators in the Gulf probably took a considerable slice from the exploration budget that had to be compensated for in other less pressing areas on land. The cost to maintain a geophysical crew on the water is many times that required to keep a crew in the field on land. Therefore, it may be logical to suspect that this increased activity in the offshore areas was made at the expense of onshore activity.

In accounting for the upswing in geophysical activity in South Louisiana, the discovery picture of last year should not be overlooked. South Louisiana is noted for its prolific fields, and several were brought in during 1954. Deep, high-pressure reservoirs were tapped, and significant discoveries were made by less than major operators. Perhaps this success story in South Louisiana has attracted more than usual attention that has expressed itself in the form of more geophysical crews active.

Texas Increases. In Texas, the increase in geophysical activity has not been concentrated in any one particular area. More crews were added in most of the reported areas. West Texas has predominated the geophysical picture for many years, and continues to do so. There have been, however, no appreciable changes in recent months to

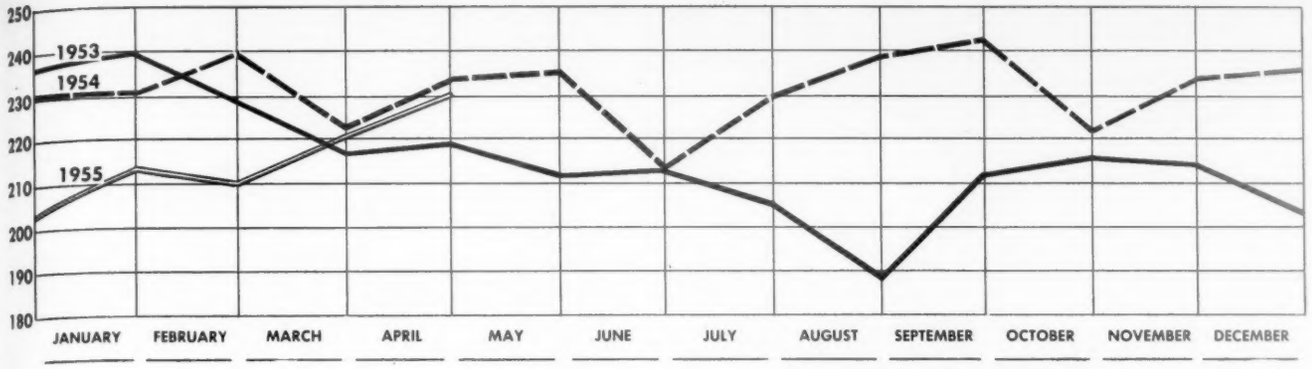
TABLE 1. U. S. Geophysical activity by methods.

1954	Seismograph	Gravity meter	Magnetometer	Total
January	585	97	7	689
Febraury	582	89	7	678
March	586	89	8	683
April	597	91	10	698
May	599	95	9	703
June	611	91	9	711
July	597	95	10	702
August	584	92	9	685
September	591	93	8	692
October	573	84	9	666
November	567	84	8	659
December	544	74	8	626
Year Totals	7016	1074	102	8192
1955				
January	545	78	9	632
February	545	79	8	632
March	551*	79	10	640
April	567*	84	11	662

* Estimated—Data not complete. Based on reported increase in Texas and Louisiana.

TABLE 2. Geophysical activity in Texas.

	1953	1954	1955
January	230	239	213
February	239	227	209
March	223	218	221
April	233	219	239
May	235	212	
June	213	213	
July	230	205	
August	238	189	
September	242	212	
October	222	216	
November	233	214	
December	236	203	
	2774	2567	



—Data courtesy the Interstate Oil Compact Commission, Oklahoma City.

FIG. 2. Total geophysical activity, including seismic, gravity meter, and magnetometer crews, for Texas since January, 1953.

suspect a big boom. Here again, seismic methods account for the major portion of activity. Total number of crews in the Permian Basin area has remained near the 75 mark, reaching a low in August 1954 of 54 crews. The high point was in February and again in April of 1953 when a total of 80 crews was active. Southwest and Southeast Texas (including the Gulf Coast) accounted for the more significant gains experienced in recent months. Other gains were general throughout the state.

Improved Methods Help. No statistical data are submitted to back up the idea that better equipment and methods may have had some influence in increasing activity. In the past three years, new ideas and refinements, however, have advanced the accuracy and speed and reduced cost in making surveys. Techniques were developed that permitted usable records to be made in areas where good records were not possible before. How much this factor has effected activity cannot be evaluated.

What's Happened to Those Left? Mere subtraction of the number of total crews active in April, 1955 (662), from those active at the end of May, 1953, (757), leaves 95 total crews to account for. Undoubtedly, many of these were shut down, equipment stored, and personnel transferred or absorbed by other industries. Foreign activity is up, and no doubt some of this group was put to work in foreign countries. More and more smaller companies are becoming interested in foreign exploration, and the larger ones are expanding their operations. The world atmosphere is more favorable today for petroleum exploration by U. S. operators than before World War II, and it is logical to assume that such a transfer has occurred.

Weather. Considerable importance has been attributed to weather conditions as to their effect on geophysical activity. In limited areas such as the Rocky Mountains and the offshore waters of the Gulf of Mexico, it is true that weather plays an important role in how much work can be done outdoors by a geophysical crew. Weather is an important factor in geophysical activity in Canada, where extreme temperatures are experienced. For the most part, weather is not, however, so significant when considering the U. S. as a whole. The curve may dip slightly in December and January, but there is no big drop such as was experienced last year.

The Effect. The greatest detriment to the geophysical industry, primarily to the geophysical contractor, in this downward trend in activity has been economic. He has suffered a loss of revenue for an extended period that only a financially strong organization could endure. When no work was in sight for his crews, they had to be let off, and many technicians sought steady employment in other fields. Men experienced in electronics and geophysics are difficult to replace at a time when a shortage exists for individuals of this specialized training.

Out of what may seem a bad situation have come some good things. The geophysical industry will be the first to admit that during the peak of activity in 1953, the quality of the average field man was below normal. This was expected when new recruits with little or no experience had to be brought in. In the personnel picture, at least, the more qualified and the more experienced have remained. As a result, the geophysical industry today is staffed with high-caliber personnel.

With the slackening of work, competition among the contractors became keen. In order to make a profit, they had to devise means of improving operations. This meant better equipment, improved techniques, cutting the time from shooting to interpretation. From this competitive era has come significant advances in geophysics.

What's Ahead. It is easy to extrapolate an ascending curve to some desired ultimate point. And to do so in the case of the upswing in geophysical activity would forecast an unrealistic picture for the remainder of the year. It is comforting to all concerned to see that activity is on the increase. How far will it go? When will it decline, and why? Only the man with the glass ball would venture an answer. All indications now lead to the conclusion that for the remainder of this year, at least, geophysical activity in the U. S. will be healthy and will probably surprise the geophysicist himself.

TABLE 3. Geophysical activity in Louisiana.

1954	Seismic	Gravity	Total
February	97	15	112
March	104	18	122
April	107	18	125
May	115	22	137
June	123	19	142
July	118	21	139
August	114	20	134
September	110	16	126
October	109	15	124
November	109	15	124
December	106	15	121
1955			
January	101	15	116
February	119	14	133
March	118	14	132
April	127	17	144
May	125	22	147

TABLE 4. Geophysical activity in the U. S.

(Includes Seismic, Gravity and Magnetometer)

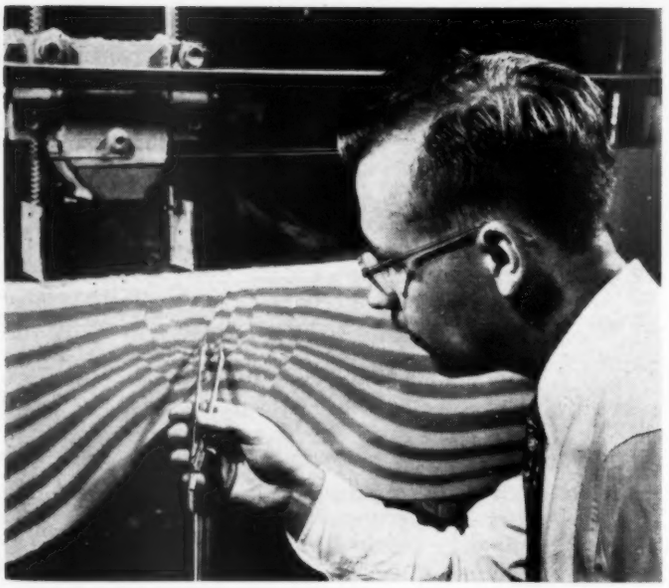
	January	February	March	April	May	June	July	August	September	October	November	December	Totals
1953	726	701	710	727	757	705	722	741	740	722	717	705	8678
1954	689	678	683	698	703	711	702	685	692	666	659	626	8192
1955	632	632	640*	662*									

* Estimated—Data not complete. Based on reported increases in Texas and Louisiana.

Acknowledgment

Data on U. S. geophysical activity were generously furnished by the Interstate Oil Compact Commission at Oklahoma City, Oklahoma, through the courtesy of Earl Foster, executive secretary, and his staff. The author is grateful to those geophysical contractors and exploration managers who contributed their ideas on this subject.

* * *



Formation of faults in the rise of a salt dome are revealed by the "time machine," and are pointed out by the machine's inventor, Dr. J. B. Currie of Gulf Research and Development Company.

Time Machine [Recreates Geologic History

Device Gives Gulf Oil Researchers Valuable Clues on the Formation of Petroleum Structures

GULF Research and Development Company of Pittsburgh, Pennsylvania, is using a device referred to as a "time machine" to recreate 200,000,000 years of the earth's history in a matter of hours to learn more about how structures grow. The machine creates a growing, cross-section model, about three feet wide, of how the earth's rock strata in oil field regions have been formed and fractured throughout geologic time.

It shows how and where faults may develop in the earth's structure, forming traps that today may conceal oil thousands of feet underground. And it gives oil men new data for locating these pools. The device "relives" earth history by depositing layers of a granulated mineral that repeat in miniature the slow build-up of sediment above the earth's basement rock. The deposits simulate the strata of sands, dusts, and shales that now lie under our feet.

Likewise reproduced is the centuries-long rise of salt domes (characteristic of certain oil regions), in which salt deposited in ancient seas is forced upward by the pressure of heavier rocks upon it.

Dr. J. B. Currie of the laboratories' geology division, developed this apparatus over the past three years. Within it, he has scaled down to the scope of a working model the physical dimensions of the earth's crust, forces and strength of materials, and in so far as possible even time itself. Thus, the depositing of one-thousandth of an inch of simulated earth in the model represents, on the average, the passage of 15,000 years of time. And to recreate 100,000,000 to 200,000,000 years takes about one to two hours. In physical measurements, an inch of deposit represents 1000 ft, so that in the experiment 8 to 12 in. simulates the depth of the original salt bed.

The material that reproduces the earth itself is powdered barium supphate, colored to differentiate various strata. This mineral, about half as heavy as lead, was selected because it compacts itself to the proper density without artificial pressure and recreates geologic reactions to stress at model scale. The miniature earth so formed is not ideal, tending to be slightly too rigid in the top layers and too fluid at the bottom. A high degree of accuracy in mirroring geological forces, however, is achieved in the central layers, so the studies are concentrated there.

In operation, the "time machine" forms its earth strata by means of a sifter on an overhead track that deposits the barium sulfate into a glass frame, 3 ft by 21 in. by 2 in. The deposits are then deformed from below by a motor-operated shaft. This pushes a dome-like head, representing a rising salt dome, up into the simulated earth mass. The dome can be widened, narrowed, or angled to 5 deg to mimic various natural formations.

Salt Dome Areas Checked

To check results, Dr. Currie has developed a method for making comparisons with fractures and oil pool locations found in thoroughly drilled oil fields. These studies have confirmed the usefulness of the "time machine" method. The model reproduces only geological areas where a salt dome is the active, deforming force (not where salt has passively flowed into areas of lower pressure).

Not a prospecting tool like the seismograph or magnetometer, the "time machine" is a theoretical instrument designed to assist field men to plan operations in the light of more complete knowledge.

The "time machine" shows that certain faults, which may trap oil, become inactive and are buried as the dome rises. They sink progressively deeper within the earth's crust, and their angle and spatial relation to the dome alter more and more as the dome continues to "grow." The changing locations of these faults, and their possible associated oil pools, at different stages of salt-dome rise are being revealed by the model in a manner difficult to calculate by other methods. Investigations of this nature with the model are providing oil exploration men with an additional technique for interpreting underground phenomena, some of which have been puzzling. * * *

AREAS OF PROMISE RECALLED

Great Basins' Future Expanded

Ernestine Adams

AREAS considered of great promise by geologists and operators were the subject of a series of symposiums in *The Petroleum Engineer* beginning in 1951.

These articles covered geology, drilling practices, mud problems, oil and gas fields of special interest in the area and the possibilities of petroleum exploration and development about each of the great basins that had shown some promise of oil and gas.

At the time development was in the early stages in Williston Basin, Uintah, Denver-Julesburg, San Juan, Anadarko, Midland, Powder River, and other areas. Most of them were barely touched by the drill. They had been largely ignored before and during World War II because the problems of recovering oil and gas and marketing them at great distances made the basins an economic hazard even after finding production.

The leap in demand after the war and the Korean episode, brought the basins into prominence. This month we review petroleum activity in these areas that showed promise.

Enough promise has been fulfilled to show that most of the possibilities envisioned three or four years ago were conservative. The same authors who earlier covered various phases of the basins' development, review the progress of six areas of promise in the following pages.

In each instance progress has been solid and impressive. The industry has advanced on all fronts so that there are no deep gaps in the line of development.

Techniques have improved and have been adapted to specific area. As production has grown, an orderly development of gasoline plants, refineries and pipe lines has taken place.

Great Basins of Petroleum Promise.

And what of the future? Are the basins still areas of promise? Does oil and gas remain that can be found and marketed economically? In the review by specialists of the areas, there is strong evidence that activity so far expands the early promise of each region.

Exploration parties are still busy seeking new locations, drilling rigs are spread widely over these seabeds of other geological ages, new fields and new producing sands are being discovered.

The great basins are still "Areas of Promise."

Williston Basin	*Donald F. Towse*
Julesburg Basin	*R. W. McCanne*
Uintah Basin	*Dorsey Hager*
San Juan Basin	*Paul H. Umbach*
Midland Basin	*James C. Watson*
Powder River Basin	*W. E. West, Jr.*

AREAS OF PROMISE RECALLED

Williston Basin

Donald Towse*

IN the four years of development since North Dakota's first oil discovery in 1951, the industry in the state has grown and become fully integrated. The state now has 521 producing oil wells in 21 different pools. Total oil production to date is more than 16 million barrels. A 30,000-bbl-per-day refinery is operating at Mandan, and 2000 and 1500 bbl refineries have been built in Dickinson and Williston. Nesson anticline gas is now processed at Signal Oil and Gas Company's Tioga gas plant, where a full line of by-products is produced. Dry gas from the plant is being flared, but the Montana-Dakota Utilities Company is planning a pipe line to points east as far as Minot.

Crude oil from the Nesson anticline goes by pipe line to the refinery at Mandan, and a product line carries refined products from Mandan east to Fargo and connections in the upper Midwest pipe line system.

Drilling

In 4 years 16 fields have been discovered; 8 of them were found in 1953. Both wildcatting and field development have been on the increase (see Table 1) every year, although 1955 has set a slower pace to date. Two new discoveries are indicated in Bottineau County for 1955.

Leasing and geophysical activity are down from last year, continuing the drop begun in 1953. The older fields are now nearly fully developed, and wildcatting has taken a turn toward evaluation of leases and geophysical prospects. Five hundred twenty-one producing wells had been completed by the end of May.

Oil Fields

The oil fields can be divided into three groups: Nesson anticline, Bottineau County, and Billings-Stark County. The first discoveries were at Beaver Lodge and Tioga on the Nesson anticline in northwestern North Dakota. Eleven fields (see Table 2) have now been developed in McKenzie, Williams, Mountrail, and Burke counties. They lie on separate closures on the main structure and have variations in pay thickness and production through porosity changes in the Madison limestone pay. All the fields produce from the Madison limestone except the Sanish field on the east flank which produces from locally developed porosity in the Mississippian Sanish sand. Tioga and Bever Lodge are the largest fields.

The Bottineau County fields are in an area that combines local structure with facies-porosity changes in the Charles and Madison formations. Porosity variations make for irregular and variable production. The Bottineau County fields are small, but some wells are good and producing depths are shallow. Northeast Landa and North Westhope fields have been the largest producers. Two new indicated discoveries is Bottineau County are Lion Oil's Skarphol well 8 miles east of the Northeast Landa field, and Amerada's Beauchamp well, 11 miles southeast of the one-well Westhope field.

Most of the production from the Fryburg field in Billings County is from the Madison formation, but one well produces from the shallower Heath sandstone (Mississippian). The Belfield field, 3½ miles northeast of Fryburg, in Stark County is a one-well Heath field. Both fields are on anticlines discovered by seismograph.

New production problems have been met in all of the North Dakota fields. The carbonate reservoirs have irregular permeability, some wells require acidization or fracturing, and water content is varible and sometimes unpredictable.

Pay Zones

Most of the North Dakota production is from limestones and dolomites of the Mississippian Madison group. Most important pay is in fragmental limestones of the Madison or Mission Canyon formation. Porosity is in multiple interfingering thin fragmental zones with some fracturing. This is the main pay on the Nesson anticline.

The Charles formation, above the Madison, is a producer in some of the Bottineau fields, where the facies change between Charles and Madison is variable. The rock is limestone and dolomite with included anhydrite and siltstone.

The Sanish sand in the Sanish field is a fine-grained sandstone in the lower part of the Mississippian system. Similar sands in that interval have been found with small shows on the top of the Nesson anticline, but the sands were tight.

The Heath sand is another fine-grained sand found near the top of the Mississippian Big Snowy group above the Madison. Production is from Heath at Fryburg and Belfield.

Light oil was produced from Devonian dolomites; and light oil, condensate, and gas were produced from Silurian dolomite in the first Beaver Lodge wells. Present development and production is entirely in the Madison there.

Exploration

Drilling this year is largely in the Nesson anticline area and the shallow Bottineau County trend, with a few deep tests drilled on seismic structures in the western part of the state.

Last year saw an intensive campaign to try to extend the production in the Lodgepole formation from Manitoba down into Rolette and Benson counties. Much subsurface information was collected, but no oil was found. This in-

*Consulting Geologist, Dickinson, North Dakota.

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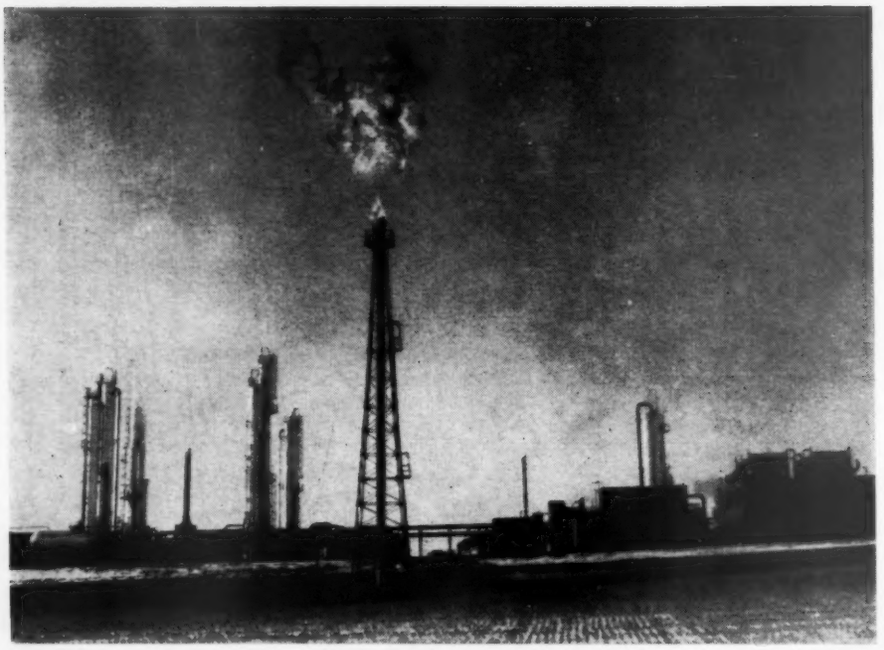

Signal Oil and Gas Company's $15,000,000 plant at Tioga, North Dakota. It processes about 60 million cubic feet of wet gas a day; produces 250,000 gal of gasoline and 50 tons of sulfur.

formation may be digested and lead to another spurt of activity sometime in the future.

Seismic work in the eastern part of the state has not paid off, but solution of the problems of the glacial drift and utilization of shallow mapping methods on the various unconformities may be expected and will help intelligent location of future strat tests. Eighty-six tests were drilled in the eastern part of the state last year. Unconformities on the rocks older than Mississippian have not been extensively tested.

Activity continues around the Bottineau County area, where more subsurface information is making it possible to map local structures heretofore unknown and to delineate more exactly the porosity and facies changes in the Madison and Charles there.

Drilling in the deeper basin parts of the state has been disappointing. Deep wildcats are widely scattered throughout the area. Many were drilled on supposedly good seismic structures, but to date either porosity has been lacking in the deep-buried carbonates, or too much water has been present. Fields at Belfield and Fryburg prove the possibility of oil, and the many shows and near-commercial tests provide encouragement. Some refinement of seismic techniques is probably needed, together with a better understanding of the porosity changes in the deeper carbonates.

Although the Red River formation (Ordovician) has produced in Montana and South Dakota, no production has been developed in North Dakota. Some shows have been reported in it and in Ordovician sands. The upper productive porous zone of the Red River is widespread and may develop production on structure.

The Heath sand produces oil in Billings County and pinches out and changes facies south and east of there. Strat traps combined with some structure may be uncovered south and east of the present production, but will probably only be found as an incident to drilling on closed structures. The 8000 to 9000 ft depths there are beyond the usual limit of present-day stratigraphic tests.

Irregular distribution of the Sanish sand on the Nesson anticline flanks may make some combination-type traps there. The irregular porosity and water levels in the Madison on the Nesson anticline may provide other fields like the McGregor field in areas not on the crest of the main structure. The discovery of a new Madison pay in the McGregor area was one of the highlights of 1954 in North Dakota.

Even at short distances from production on the anticline, possibilities are nowhere near being drilled out, and in most parts of the state the ground is hardly scratched.

Mesozoic formations have not provided any encouragement, but pinchouts of Cretaceous sands are known to exist, although drilling has not pinned them down exactly. The Jurassic has favorable reservoir characteristic and is so far untouched.

The feverish activity of the early days has cooled off now, especially among the smaller independent operators. We now expect for North Dakota the normal oil-country cycle of flurries of drilling activity separated by long lulls for digestion of information. Combinations of subsurface structure and stratigraphic exploration will test some of the many possibilities and continue to contribute to oil discoveries here as they have done in other places. Judicious use should be made of refined seismograph methods and computing and shallow mapping methods, combined with the structure core-drill and the stratigraphic test.

North Dakota has grown out of its oil babyhood; but, like any four-year-old, it still has a long way to go.

TABLE 1. Drilling in North Dakota.

Year	Wildcat oil wells	Wildcat dry holes	Total wildcats	Field oil wells	Field dry holes	Total field wells	Discoveries
1951	1	9	10	0	0	0	Beaver Lodge field
1952	4	40	44	87	15	102	Tioga, Charlson, Croff, Hofflund fields
1953	8	72	81	167	13	180	Fryburg, N. E. Landa, Westhope, N. Westhope, Keene, Sanish, E. Tioga, Capa fields
1954	3	115	118	185	7	192	McGregor, White Earth, Belfield fields

TABLE 2. North Dakota Oil Fields.

Field	County	Pay	Cumulative production to April 30, 1955	Wells producing May 31, 1955	Field	County	Pay	Cumulative production to April 30, 1955	Wells producing May 31, 1955
Fryburg	Billings	Madison	239,528 bbl	12	Tioga	Williams, Mountrail, Burke	Madison	6,172,801	185
Fryburg	Billings	Heath	803	1					
Croff	McKenzie	Madison	42,504	1	E. Tioga	Mountrail	Madison	116,125	9
Charlson	McKenzie	Madison	567,114	35	White Earth	Mountrail	Madison	139,899	10
Keene	McKenzie	Madison	16,115	1	NE Landa	Bottineau	Madison	51,061	9
Sanish	McKenzie	Sanish sd.	105,694	3	Westhope	Bottineau	Madison	3,587	1
Capa	Williams	Madison	258,737	18	N. Westhope	Bottineau	Madison	70,030	11
Hofflund	Williams	Madison	220,673	10	Landa	Bottineau	Madison	22	1
Beaver Lodge	Williams, Mountrail	Madison	8,263,085	204	un-named	Bottineau	Madison	4,115	1
Beaver Lodge		Devonian	33,572	0	Belfield	Stark	Heath	377	1
Beaver Lodge		Silurian	3,092	0					
McGregor	Williams	Madison	78,695	8	TOTAL			16,387,629 bbl	521 wells

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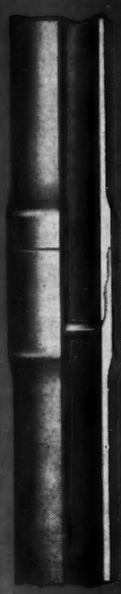

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AREAS OF PROMISE RECALLED

Denver-Julesburg Basin

R. W. McCanne*

COMMENCING with completion of the Mary Egging No. 1 at Gurley, Cheyenne County, Nebraska, by The Ohio Oil Company in 1949, exploration and development work in the Julesburg Basin has progressed at a steady and ever-increasing rate until reserves in the area are now estimated to be from 215,000,000 to 230,000,000 bbl of oil. What appeared in 1949 to be "An Area of Promise" seems still to hold promise of success for the continuing efforts by the oil industry to find and develop new reserves of oil and gas.

Drilling and Producing

Indicative of the drilling activity in the Basin is the fact that in 1949, there were only 39 wells drilled in Colorado and Nebraska. In 1950 there were 141 wells drilled, and in 1954 there were 1708. Approximately 41 per cent of all drilling done in the Rocky Mountain Region in 1954 was in the Julesburg Basin. The following table illustrates the increase in activity from 1950 through 1954:

	1950	1951	1952	1953	1954
COLORADO					
Number of fields	13				
Number of producing wells	62				
Gross production, bbl	280,517	1,625,540	3,508,763	8,653,755	21,334,653
NEBRASKA					
Number of fields	4	18	30	46	65
Number of producing wells	34	82	163	264	461
Gross production, bbl	767,952	1,664,053	1,820,097	5,865,327	7,548,236

Development has principally followed a regional trend from the northeast to the southwest from the Nebraska Panhandle to Adams and Washington counties, Colorado, with numerous producing areas having been developed in echelon to the main northeast-southwest trend. To date the producing area is some 170 miles from the north to the south and about 150 miles from the east to the west, with the length of the entire Basin some 300 miles and the width about 200 miles.

Nearly all of the production is from sands of Cretaceous age, with the chief producing sands being the First or "D" and the Third or "J" sands of the Dakota group. The Second or "G" sand produces only in a few fields, and there is some production in Colorado from the Lakota sands and the Lyons sand of Permian age. Many wells in the Basin are being drilled through the Skull Creek shale into the Lakota in the hope of finding deeper production. Though drilling into pre-Cretaceous rocks has not been notably successful thus far, possibility of production from the older sediments continues to add promise to the area.

Impetus toward deeper drilling has come from a minor Lyons sand discovery in the Keota field, Weld County, Colorado; from Lyons production in the Black Hollow field, to the west in the same county, where 10 wells are now producing approximately 200 bbl of oil per day; and from a Lyons sand discovery near Pierce, Colorado, which though not officially completed, appears capable of making about 300 bbl per day.

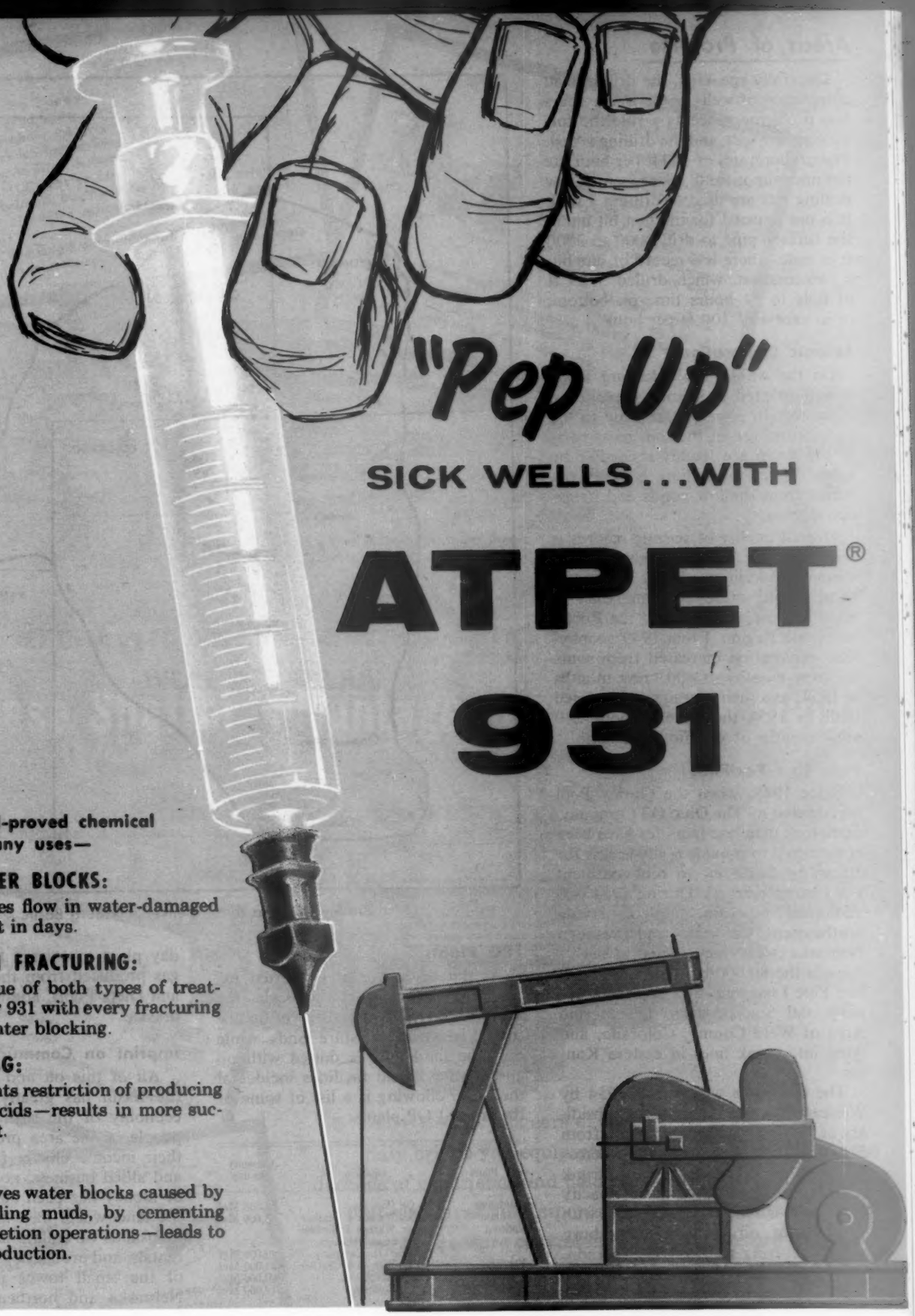
Thickness, porosity, and permeability in the principal producing sands of the Dakota vary greatly throughout the Basin. This condition causes the occurrence of frequent stratigraphic accumulations in many portions of the Basin, while oil and gas is found principally in small structural traps in the northeastern part, chiefly in Cheyenne County, Nebraska. The most important producing zone is the Third Dakota or "J" sand. Production in this sand has been found in three benches totaling from 60 to 200 ft in thickness.

As wells have been drilled on wildcat prospects, which were stepouts from the area of principal beginning interest in Cheyenne County, Nebraska, the entire Basin is now receiving attention. One of the sections of the Basin attracting increased activity recently is the southeastern portion of Wyoming where a Third Dakota or "J" sand discovery has been made in Pine Bluffs area, Laramie County.

Late in 1954 an interesting discovery was made by an independent operator in the west-central part of the Basin in Jefferson County, Colorado, 10 miles west of Denver along the mountain front. This latter well produced from the Codell sand, previously unproductive, and was drilled in an area of complicated faulting where drilling is much more difficult than is usual in the Julesburg Basin. Economically this discovery does not appear to be important, but geologically it indicates that oil is present at great depths in an area of faulting and thrusting along the mountain front.

Since 1952, two fields of major importance have been found in the Colorado portion of the Julesburg Basin. Little Beaver-Badger Creek, Adams and Washington Counties, Colorado, was discovered in 1952 and by the end of that year was producing more than 10,000 bbl of crude per day. Late in 1953, the Adena discovery was made in Morgan County, Colorado, and production from that field is now around 17,000 bbl per day. In view of the fact that previous to these discoveries, few fields in the area produced more than 4000 bbl per day, Little Beaver and Adena awakened all producers to the potential importance of the Basin as a major oil-producing province. It is estimated that the reserves at Adena are some 50,000,000 bbl and at Little Beaver-Badger Creek about 9,000,000 bbl. Adena is now second only to the Rangely field in daily production in the State of Colorado.

*Division Manager, Ohio Oil Company, Casper, Wyoming.



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Areas of Promise

Generally speaking, the drilling and completion of wells in the Basin offers few problems, since as a rule the formations are soft, and the drilling is fast. Penetration rates of 150 ft per hour are not uncommon; and, consequently, few drilling bits are used in drilling a well. It is not unusual for the first bit under the surface pipe to drill 2000 to 3000 ft of hole. There is a record of one bit, a two-cone jet, which drilled 5929 ft of hole in 54 hours time on bottom, or in excess of 100 ft per hour.

Seismic Exploration

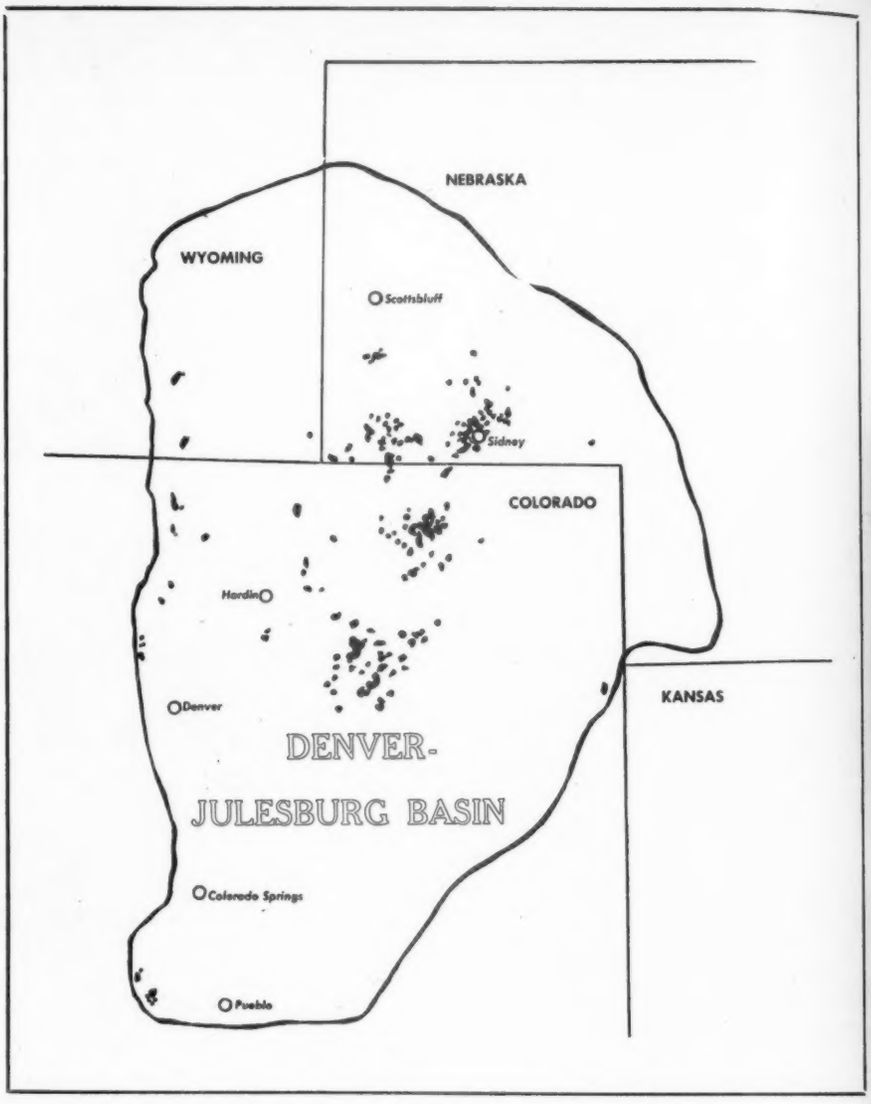
On the whole, the Julesburg Basin is well-adapted to seismic exploration —the terrain is gentle and due to the agricultural use of the soil, most parts of the Basin are readily accessible by roads. Water for drilling is easily obtained from shallow ponds and irrigation ditches.

Overall quality of seismic records is above average, and as a general rule seismic work in the Basin is less expensive and more accurate than is usual in most other parts of the Rocky Mountain Region. From 1949 geophysical exploration increased from some 93 crew months to 400 crew months in 1951, and then it gradually declined until in 1954 there were about 240 crew months of seismic work done.

Pipe Line Facilities

Since 1949, when the Gurley Pool was opened by The Ohio Oil Company, numerous pipe line facilities have been constructed to provide ready access for Julesburg Basin oil to mid-continent and eastern markets. During 1954 two additional pipe line outlets serving northeastern Colorado and western Nebraska were constructed. One of these is the 80,000-bbl-per-day Arapahoe Pipe Line built by Pure Oil Company and Sinclair from the Merino Area of Weld County, Colorado, and tying into trunk lines in eastern Kansas.

The other line was laid in 1954 by Western Pipeline Company, a subsidiary of Service Pipeline Company, from Fort Laramie, Wyoming, south across northeastern Colorado to tie into trunk lines also in eastern Kansas. Capacity of this line is 160,000 bbl per day, with injection of oil from the Julesburg Basin occurring at Sterling, Colorado. This line connects with Service Pipeline in Wyoming and replaces the 60,000-bbl-per-day line across Nebraska. For many years before the construction of the Platte Pipe Line from Worland, Wyoming, to Wood River, Illinois, this line was the only outlet for Rocky Mountain crude to midwest and eastern markets. Adequate pipe line facilities are lending encouragement to continued exploration and development in the Basin.



Producing areas in the Denver-Julesburg Basin.

LPG Plants

At the beginning of concerted exploration effort within the Basin, the area was composed mostly of undisturbed wheat and pasture lands, while now the landscape is dotted with oil and gas fields and facilities incidental thereto. Following is a list of some of the larger LGP plants:

Plant	Operator	Capacity per day
Huntsman	Ohio Oil Company	12,500 Mcf
Dorman	Ginther, Warren & Ginther	3,000 Mcf
Padroni	Ginther, Warren & Ginther and Kansas-Nebraska Natural Gas Company	10,000 Mcf
Yenter	Ginther, Warren & Ginther	21,000 Mcf
Little Beaver	Continental Oil Co.	20,000 Mcf
West Sidney	Ohio Oil Company	12,000 Mcf

In addition there are numerous smaller compressor plants throughout northeastern Colorado and western Nebraska. At the present time, Pure Oil Company is constructing a 20,000-Mcf-per-day gasoline plant in the Adena Area, Morgan County, Colorado; and the Kimball Gas Products Company is building a 7500-Mcf-per-day plant to extract liquids from the gas produced from the Enders, Long, and Dietz Pools, Kimball County, Nebraska.

Imprint on Communities

All of this oil and gas industry in the Basin has greatly influenced the economy of the region. Whereas the people of the area previously derived their income chiefly from agriculture and allied business, now a new source of money has been added. Of course, the landowners have been paid many thousands of dollars in lease bonuses, rentals, and production royalties. Many of the small towns in southwestern Nebraska and northeastern Colorado have been swelled with personnel employed by operators and service and supply companies.

Denver has felt the greatest impact from all of this activity, since it has in recent years become the principal administrative center for exploration and development of the Basin. Sidney and Kimball have become important local oil centers in southwestern Ne-

GREATER COMPACTNESS!

Because of the side-opening doors, no extra space need be allowed above the gate—or at the ends—for servicing rams. Even in sizes as large as 13⅜" (12" Series 900) Shaffer Hydraulic Double Gates have a *total* height of only 30". No extra space above or at the ends is necessary!

Width and length dimensions are also unusually compact, saving valuable cellar space in all three dimensions.

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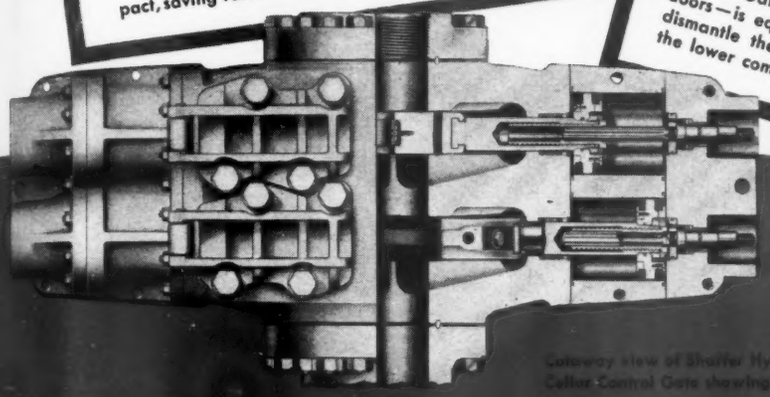
Shaffer's patented side-opening doors provide unmatched simplicity in servicing rams. Simply unbolt and open the doors—change rams—and bolt the doors shut again. Closing the doors automatically aligns the rams within the gate.

And in Shaffer Hydraulic Double Gates, each compartment has its own set of doors—is equally easy to service. There's no need to dismantle the upper compartment to change rams in the lower compartment—or vice versa.



Gateway view of Shaffer Hydraulic Double Cellar Control Gate showing simple design.

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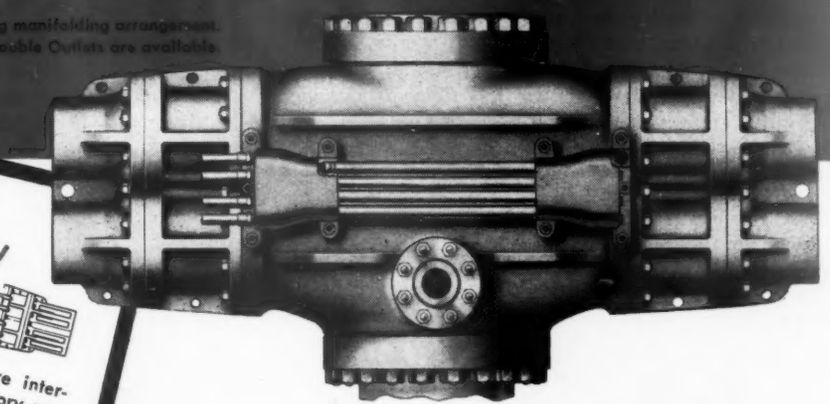
Rear View of above Gate showing manifolding arrangement. Both Single and Double Outlets are available.



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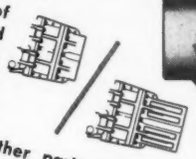
Shaffer provides a choice of Single or Double Gates...and a choice of Rising or Non-Rising Locking Shafts. Choose the type and Locking Shaft design that best meets your particular requirements. Rams and most other parts are interchangeable, size for size, for minimum inventory and maintenance costs!



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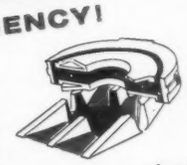

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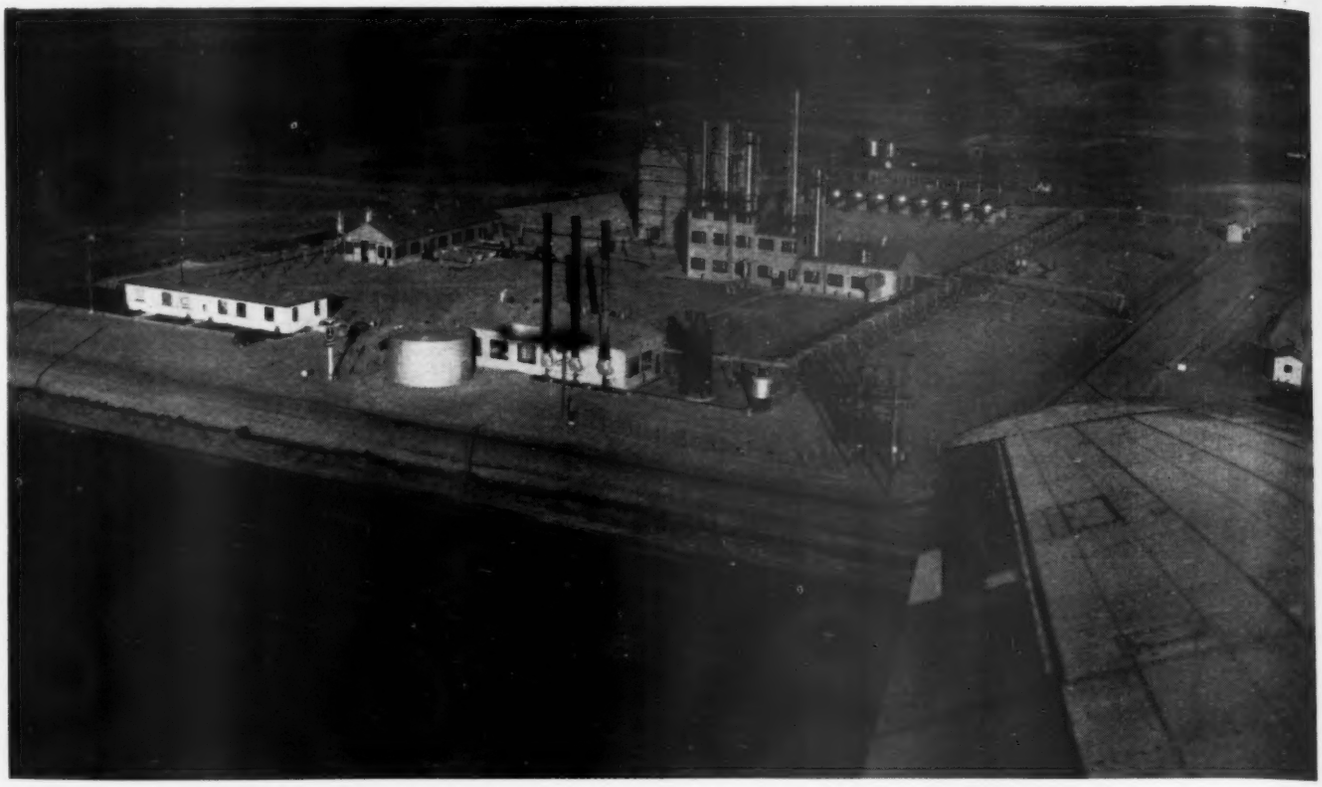
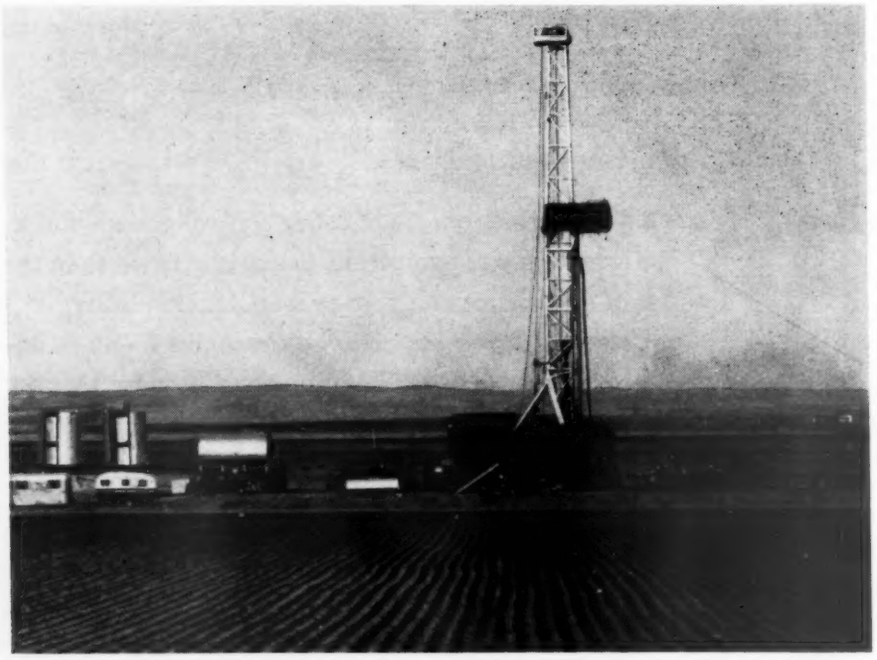


Aerial view of Ohio Oil's Huntsman gasoline plant near Sidney, Nebraska, where natural gasoline, butane and propane are extracted from natural gas produced in the Huntsman field.

braska, and Sterling, Ft. Morgan, and Brush are centers of operations in northeastern Colorado.

Of course, the influx of people in small communities caused some disturbance of what had been considered for a long time a normal way of life, but adjustments have been made now so that the initial annoyances have been largely eliminated. On the whole relations between the oil and gas industry and the local populace have been amicable, and it appears that the industry has done a good job of public relations in the manner it has handled its affairs in this new producing province.

Oil and gas people have cooperated with community leaders in solving local problems brought about by the industry's activities and have entered wholeheartedly into civic affairs. On the other hand, the long-time inhabitants of the region have taken an active interest in the oil business and have cooperated to the fullest extent. It has been interesting to watch farmers and ranchers, completely uneducated in the business of exploring for and developing oil reserves, become pretty good oil men themselves.

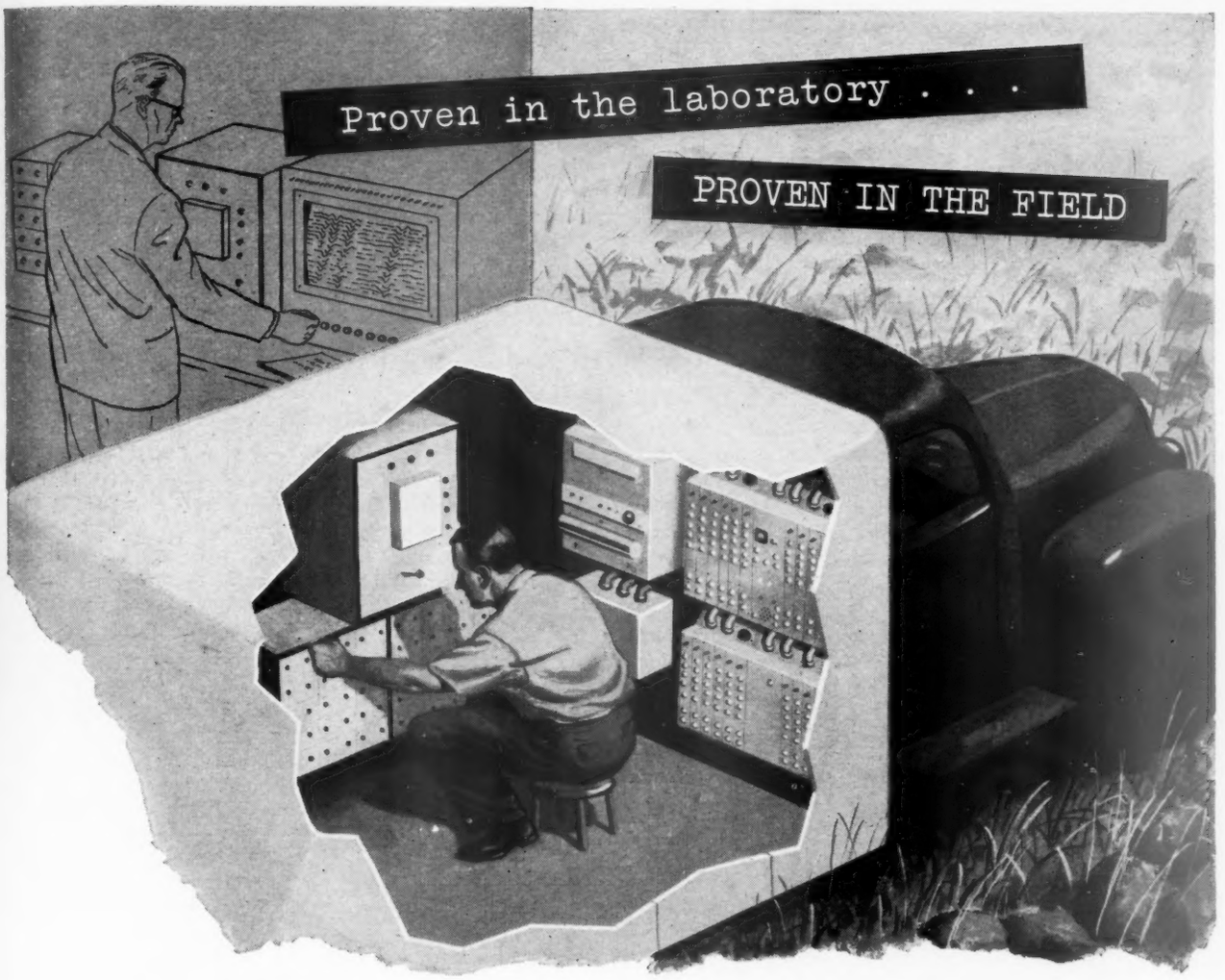


Ohio Oil's Baird Chamber No. 1, Cheyenne County, Nebraska, was abandoned as a dry hole. Out of every nine exploratory wells drilled, eight are dry holes.

Conclusion

It is felt by most operators that the Julesburg Basin is still an "Area of Promise" and that the industry will continue to invest time and money to develop the oil and gas resources of the area. Some of the reasons for this feeling are:

1. **Ease and low cost of drilling.**
2. **Comparatively shallow depth of formations which are productive in most producing wells.**
3. **Great size of the potentially productive area.**
4. **Continuing possibility of production in rocks older than Cretaceous.**
5. **High gravity of oil and good quality of gas which is sulfur-free and rich in LP-gases.**
6. **Adequate pipe line outlets to markets 300 miles closer than other Rocky Mountain reserves.**
7. **Increasing local population with attendant increased potential local market for petroleum products.**



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AREAS OF PROMISE RECALLED

Uintah Basin

Dorsey Hager*

THE Uintah Basin is unique and cannot be compared with other Rocky Mountain areas unless it is the Green River Basin, but it differs markedly from that basin. The faults and folds are of low magnitude within the Basin although more pronounced on the periphery.

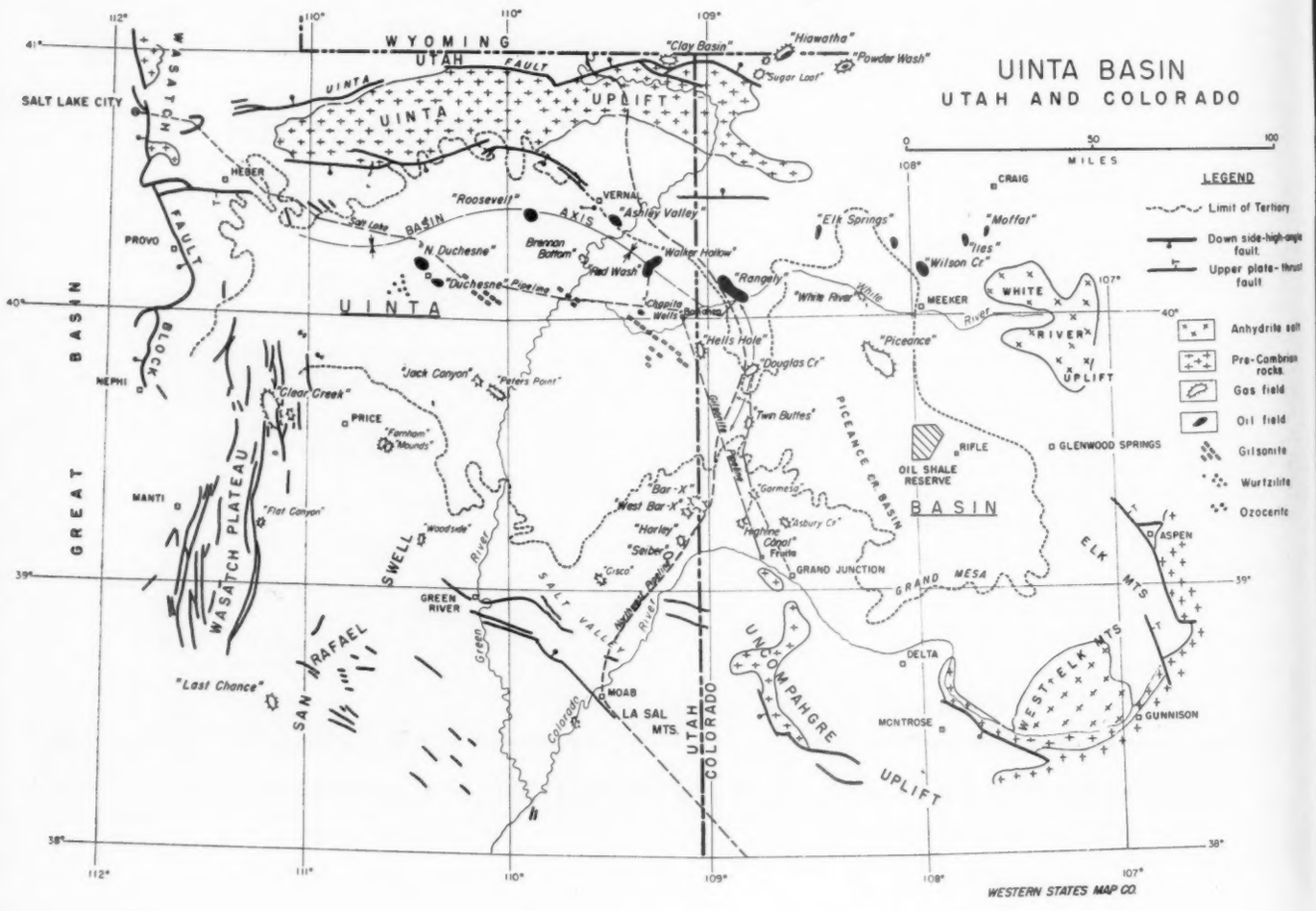
Accumulations of gas and oil in the Uintah Basin except Rangely, Colorado, and its extension into the Piceance Basin (Rangely is a marked anticlinal fold of large proportions) are governed largely by changes in sedimentation, lensing of sands up-dip, and fractured shales (statigraphic traps.) Only a few folds and faults show at the surface in the Tertiary beds and there is insufficient subsurface evidence available at present to define the underground conditions. To find the possible traps will require much new drilling, much new geophysical work, and most careful testing, but there is a thick section of beds with which to work. (See Table I.)

Some of the finger-like folds that are echelon to the Uncompahgre Uplift and which plunge into the Uintah Basin should be found by either "strat" holes or by seismic and other geophysical methods.

After 7 years of drilling in the Uintah Basin of Utah 100 wildcat holes resulted in the discovery of 5 oil fields, 2 possible oil fields, and 4 gas fields, the question is still asked, "Is the Unitah Basin going to 'pay out'?"

The Standard Oil Company of California took over the California Company operations at Red Wash. Thirty-seven wells have been drilled proving over 10,000 acres, perhaps as much as 12,000 acres. Expected recovery conservatively ranges from 40 to 60 million barrels. The oil is found principally in sandstones which pinch out to the southeast. They occur on a very broad northwestward plunging nose. This is a statigraphic trap field.

*Consulting Geologist, Salt Lake City, Utah.



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Sand-fracturing has proved successful in this field, increasing initial yield from 100 to 400 per cent. Rotary tools are used in drilling. Costs are high, $180,000 per well average completion in tanks. The average daily production is 2150 bbl, roughly 60 bbl per well.

On the Colorado side the Rangely oil field is of course a major oil field with 20,000 acres developed. Deeper possibilities to the Mississippian beds there have been tested by one hole drilled by The Texas Company. That hole was dry. It would appear that the potentials at Rangely are confined to the upper beds. The field is completely drilled to the Weber sandstone with a daily present production of 61,567 bbl from 546 wells. Reserves are considered to last an additional 25 years, more or less. The total ultimate production is in the neighborhood of 350,000,000 to 400,000,000 bbl.

The total daily production from the Uintah Basin of Colorado is 61,567 bbl and from the Utah side of the Uintah Basin the daily production is 5798 bbl.

Possible 'Pays' in Uintah

The possible oil and gas "pays" occur in beds that range from 20 ft to 40,000 ft in thickness (see Table I) thinning from East to West. In the central part of the Basin 30,000 ft should allow penetration of the basal complex. However, on the periphery of the Basin depths will be considerably less, and beds of the Weber sandstone should be tested from 13,000 to 15,000 ft.

Gas and Oil Fields—1953-1955 (Table 2)

In 1953 the County oil field was opened. The Carter Oil Company discovered this field, which produces a heavy 25 API low pourpoint oil from depths of 5257 ft, some 300 ft above the main "pays" in the Green River beds.

In 1954 Gulf Oil Company drilled a hole at Brennan Bottoms, Uintah County, which was a field opener at a depth of 6800 to 7000 ft in lower Green River beds.

Gas up to 2,000,000 cu ft daily was found by the Cities Service Oil Company in the Wasatch beds at depths of 2800 to 3800 ft at Peters Point. Also, some oil was found in one of the El Paso Gas Company's test at Firewater Canyon, but not commercial. These were the first important discoveries of gas and oil in the Wasatch beds. Later tests at Peters Point, at Jack Canyon, and at Chapita Wells have resulted in commercial gas wells.

Deeper sources, however, will be found in the Mesaverde beds which can be penetrated deep in the Basin, around 15,000 ft. As the periphery is approached, the depths to the Mesaverde decrease rapidly. One test to the Mesaverde has shown oil so far, and that is the Chapita Wells test of the Continental Oil Company which made a small well of light oil.

Discovery Rate

All the dry holes drilled within the Tertiary Basin show a discovery rate now of 1 out of 10 prospect holes.

The producing gas and oil areas in the Basin in Colorado and in Utah are not over 100 square miles of proven area, or one square mile of proven area to 200 unproven. In old oil-producing states like Oklahoma, Texas, and Illinois production is in the measure of one square mile productive to 16 nonproductive. Those states are mentioned because the gas and oil fields in the Uintah Basin are of different types from other Rocky Mountain areas and will more likely approximate Mid-Continent conditions, or conditions found on the East side of the Powder River Basin of Wyoming and in the San Juan area of Colorado.

Summary

Outstanding developments in the Uintah Basin are:

1. Red Wash field of the Standard Oil Company of California is a major oil field with possibilities of becoming important as a gas field.
2. Late developments in the Piceance Basin, Colorado (part of the Uintah Basin) make that an area attractive for natural gas. Important gas reserves are now being developed there.
3. On the Utah side the discovery of natural gas at Chapita Wells in the Wasatch sandstone by the Continental Oil Company; the discovery of natural gas at Bluebell in the Green River formation; the natural gas at Peters Point and at Jack Canyon, all on the Utah side, open natural gas possibilities over a wide area in the Uintah Basin. The area has barely been scratched from a gas viewpoint.
4. The start of construction of the Pacific Northwest pipe line has stimulated drilling activity for natural gas. This line cuts through the middle of the Basin (see map) and new gas fields will have ready access to the line.
5. Plans have been announced by American Gilsonite Company to build a plant at Grand Junction, Colorado to

TABLE 1. POSSIBLE GAS AND OIL "PAYS" IN UTAH

Period	Formation	Approx. thickness, ft	Possible "pays"	
TERTIARY	Gr. River sands and shales	4000	4–5	Oil, Roosevelt; Red Wash, Utah.
	Wasatch sands	2000	3–4	Gas, Peters Point, Utah; Oil at Duchesne, Utah.
UPPER CRETACEOUS	Mesaverde s.	2000	6–8	Oil, Chapita Wells, Uintah Co., Utah; Gas at West Douglas Cr., Colorado.
	Mancos shale	4000	2–3	Shallow oil at Rangely, Colorado.
	Ferron sands	150–500	5–6	Gas, Clay Basin; Gas, Clear Creek, Utah.
	Frontier sand			
	Dakota sand		1–2	Gas, Ashley Valley; Cisco; Clay Basin, Utah.
LOWER CRET.	Cedar Mountain	200–300	1	
JURASSIC	Morrison	300–500	1–2	Gas at Bar-X; Ashley Valley, Utah
	Entrada s. s.	180–400	1	Gas at Bar-X, Utah.
	Navajo s.s. (Nugget)	1000	1	Gas at Bar-X, Utah.
TRIASSIC	Shinarump s.s.	50–100	1	Oil at Ashley Valley, Utah
	Moenkopi s.s.	500–800	1	Gas, Last Chance; gas and oil, Mounds, Utah.
	Sinbad l.s.			Oil at Virgin, Utah.
PERMIAN	Kaibab-Phosphoria l.s.	50–100	1	Oil at Ashley Valley, Utah
	U. Weber-Coconino	300–400	1	Oil, Rangely, Colo.; Ashley Valley, Utah; Oil at Boundary Butte, Utah.
	Diamond Creek			
PENNSYLVANIAN	Weber s.s.	600–700		
	Morgan-Oquirrh	3000–8000	4–5	
	Paradox-Hermosa	3000–8000	2–3	Good oil showings, Cane Creek & Big Flat; gas at Boundary Butte, Utah.
MISS.	Madison l.s.	300–600	1	Oil at Upper Valley, Utah.
	Leadville l.s.			
DEVONIAN	Ouray l.s.	300	1	Oil shows at Big Flat, Utah.
	Elbert			
CAMBRIAN	Ladore Qtzite	350–400	1	Oil at Lost Soldier, Wyoming.
	Arkosic sand			

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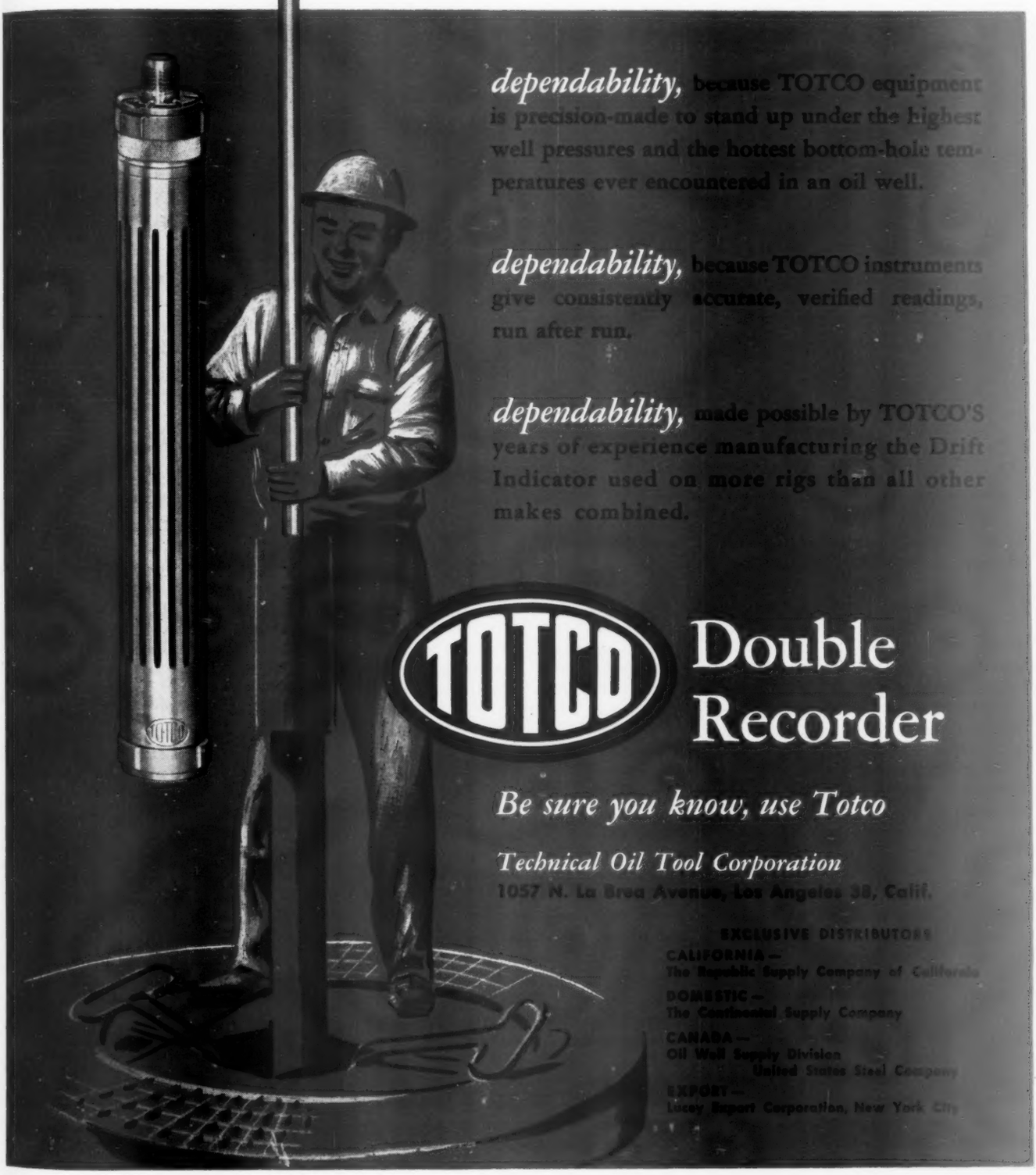

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TABLE 2. OIL AND GAS FIELDS IN UINTAH BASIN

	Field	Discovery	Type reservoir	Formation	Age	Remarks
UTAH	Roosevelt	Seismic	Fractured shales	Green River	Eocene	Oil, 8 wells
	Red Wash	Seismic Surface	Strat trap	Green River s.s. and frac. shale	Eocene	35 oil wells 2 gas wells
	Walker Hollow	Surface	Strat trap	Green River	Eocene	1 gas well, 3 oil wells
	Duchesne	Surface– Seismic	Fault trap	Green River shale Wasatch s.s.	Eocene Paleocene	Oil Oil, 22 wells
	Flat Mesa	Seismic	Strat trap	Gr. River frac. shale	Eocene	Oil, 1 well
	County Pool	Seismic	Strat trap	Gr. River frac. shale	Eocene	Oil, 2 wells
	Ashley Valley	Surface	Fold	Dakota s.s. Weber s.s. Phosphoria l.s.	Cretaceous Permian Permian	Gas, 1 well Oil Oil, 29 wells
	Jensen	Sub-surface (?)	Strat trap	Shinarump congl.	Triassic	Oil, 1 well
	Brennan Bottoms	Seismic	Strat trap	Green River	Eocene	Oil, 2 wells
	Peters Point	Geology	Nose—strat	Wasatch Mesaverde	Paleocene Cretaceous	Gas, 2 gas wells Gas, 1 drilling
	Jack Canyon	Surface Geology	Nose—strat	Green River Wasatch	Eocene Paleocene	Oil Gas, 2 wells, shut-in
	Chapita Wells	Seismic (?)	Strat	Wasatch s.s. Mesaverde s.s.	Paleocene Cretaceous	Gas, 1 well Oil, 1 well
	Bluebell	Seismic Surface	Structural	Gr. River shale	Eocene	Gas
COLORADO	Rangely	Surface	Anticline	Mancos shale Weber s.s.	Cretaceous Permian	Oil Oil
	White River	Surface	Anticline	Gr. River s.s.	Eocene	Gas
	Twin Buttes	Surface	Nose	Gr. River s.s.	Eocene	Gas
	E. Douglas Creek	Surface	Fold	Gr. River s.s.	Eocene	Gas
	Piceance Creek	Surface	Structural	Gr. River s.s.	Eocene	Gas

process 1000 tons of gilsonite daily to provide coke for aluminum for insulation, etc., gasoline, and other by-products. A pipe line will be built from Bonanza, Uintah County, Utah, to Fruita, 15 miles northwest of Grand Junction, Colorado. Ground gilsonite, floated in water, will be pumped through the line.

A large tonnage of gilsonite is available and this new development will stimulate activity in the Basin area where numerous gilsonite veins extend from the periphery northwest to near the center of the Basin. The gilsonite veins vary from one foot to 22 feet in width and extend 1000 feet and more in depth. Several veins have been traced ten miles and more. When needed, the great shale oil deposits can be exploited to furnish several hundred billions of barrels of oil.

Evaluating the Uintah Basin

In evaluating the Uintah Basin of Utah and of Western Colorado one must take a long range view. The Basin should produce much oil and gas, principally from stratigraphic traps. The area has been barely scratched by test holes. Drilling is expensive and looking for stratigraphic traps is costly, but in time as additional holes are drilled the costs will drop.

On the Colorado side of the Uintah Basin, Rangely is a major field with reserves from the Weber sandstone good for the next thirty years. The Ashley Valley oil field on the Utah side is a rich little field producing from the Weber sandstone. It produces 2761 bbl daily from 29 wells with a reserve of 7,000,000 bbl. One good oil field on the Utah side, Red Wash, is an indication that oil fields of size can be found in the Utah part of the Basin. The oil has a high wax content and high pourpoint. It congeals at 80 to 90 F. It is a good grade 40 API oil, and as demand increases this oil will be needed.

On the Colorado side five natural gas fields have been found in the Piceance Basin by the General Petroleum Corporation and by the Equity Oil Company and one at Twin Buttes by the El Paso Natural Gas Company to furnish Grand Junction with natural gas. East Douglas Creek and Coyote Basin (White River oil field) also have gas fields which have lain dormant.

On the Utah side natural gas at Red Wash, at Chapita Wells, at Peters Point and Jack Canyon, and at Bluebell indicate that definite gas possibilities also exist on the Utah side.

The gilsonite development opens a new field to the owners of gilsonite claims. How great a potential can be developed remains to be seen, but development will be stimulated.

Conclusion

Considering all these points the Uintah Basin is an important future reserve for gas and oil which will become more important as the years pass. It is not a place for the small independent oil men, but an area in which the major oil companies will gradually develop substantial reserves. The most immediate cash returns, however, will come from natural gas. Construction of the Pacific Northwest pipe line has already stimulated much drilling and on its completion, the natural gas from Western Colorado and from Utah will find a ready market at a good price, 15 to 17 cents per 1000 cu ft.

The active oil boom is over, but the Uintah Basin has too many potentialities to sell it short. Quick high profits are not in sight, but for those major concerns which are looking for reserves, the Uintah Basin should hold much promise.

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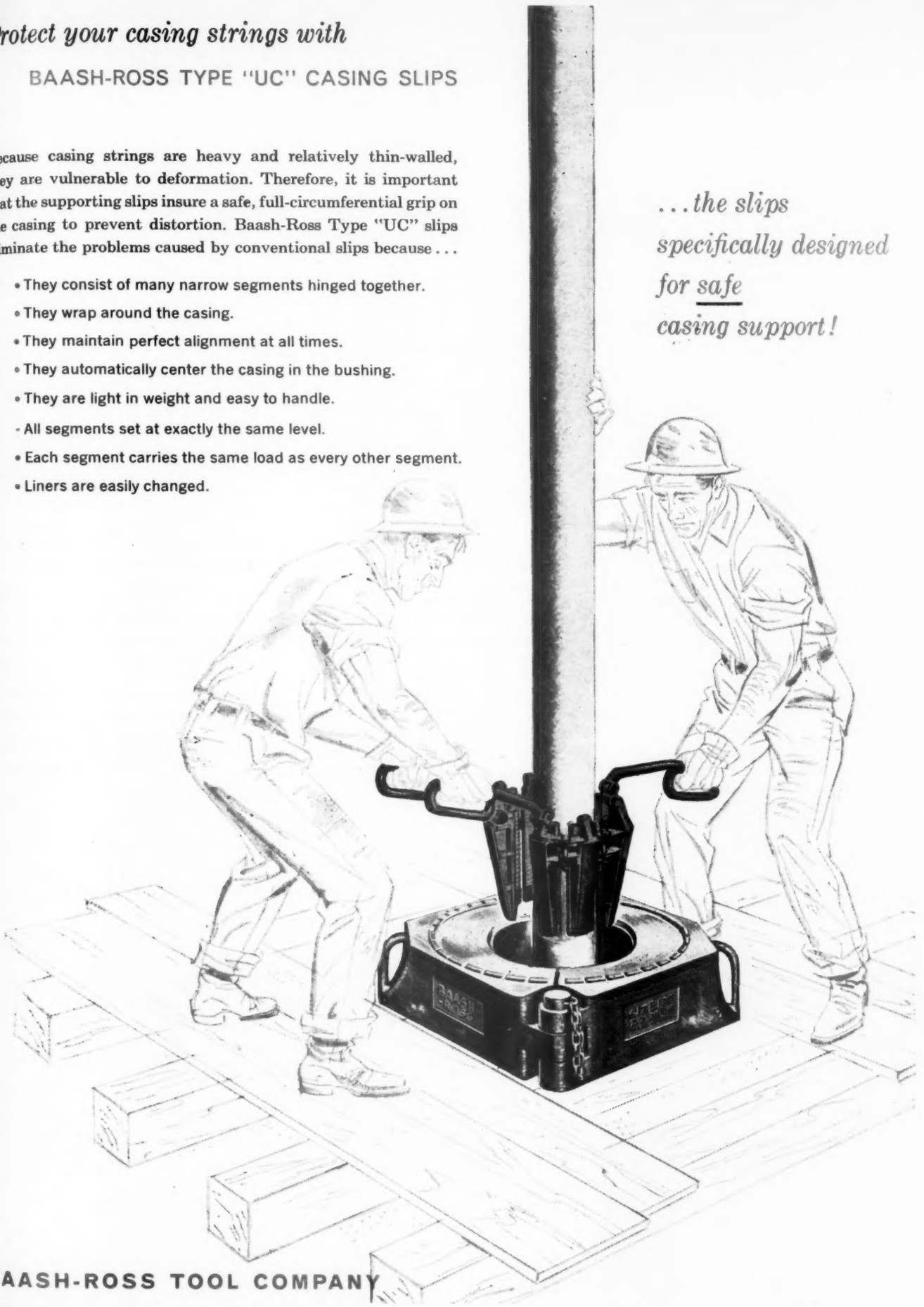

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AREAS OF PROMISE RECALLED

San Juan Basin

Paul H. Umbach*

THE San Juan Basin, in the extreme northwestern part of New Mexico and the southwestern portion of Colorado, has developed into one of the major natural gas-producing regions of the United States. The development is confined to approximately 7000 square miles within the Pictured Cliffs outcrop. Within the area outlined as the Pictured Cliffs outcrop on Fig. 1 there are over 10,000 square miles with the concentration of development within the center of the Basin. The deepest portion is approximately 15,000 ft with granite being drilled at a depth of from 5000 to 8000 ft on the outer edge of the Pictured Cliffs outcrop.

Pictured Cliffs Producing Area

Production in the Pictured Cliffs formation is confined to elongate trends of relatively high permeability, which range from 2 to 8 miles wide and from 20 to 70 miles long with the eastern limits yet to be defined (Fig. 1). The high concentration of fields is confined to the southwestern sides of the basin. Development of additional trends are expected in the central and northeastern portion of the basin.

Although the thickness of the Pictured Cliffs sandstone in the highly productive area is only from 20 to 60 ft, the reserves are expected to be high since it is proved with past production that additional reserves are being drawn from the porous but less permeable sandstone between the trends of commercial production.

Mesaverde Producing Area

Mesaverde production in the San Juan Basin is confined to the Blanco Field (Fig. 1) in the central portion of the basin. The field at this time is approximately 35 miles wide and 70 miles long with its eastern and southern limits yet to be defined.

The Mesaverde group consists of Cliff House, Menefee and Point Lookout formations, all of which are productive of natural gas. The entire group consists of a thickness of from 500 to 800 ft of sandstone, shale and coal. Although all of the section has an average porosity of approximately 9 per cent the permeability varies throughout and the recovery factor and effective pay are always questioned resulting in a controversy with reference to reserves. In all cases the rate of production over a period of 30 years is less than the reserves obtained by porosity volume calculation, with no discount made for zones that might not be considered effective pay.

Lower Mancos Multiple Zones

Recent widely scattered discoveries of oil and gas in the multiple sandstone zones of the lower Mancos have assurance of adding to the high reserves that are well established in the Pictured Cliffs and Mesaverde although not shown on Fig. 1. El Paso Natural Gas Company's and Skelly Oil Company's gas discoveries west of the West Kutz Field in multiple sandstone zones of the Mancos have early indications of establishing a strand line trend of production similar to that established in the Pictured Cliffs.

Although of small commercial importance at this time, the discoveries of oil near the Sandoval-Rio Arriba County line could develop into a significant reserve with additional drilling. The field limits of oil development in the Mancos Sandstone Stringer at Dogie Canyon (Fig. 1) are yet to be defined although the field is producing approximately 35,000 bbl per month.

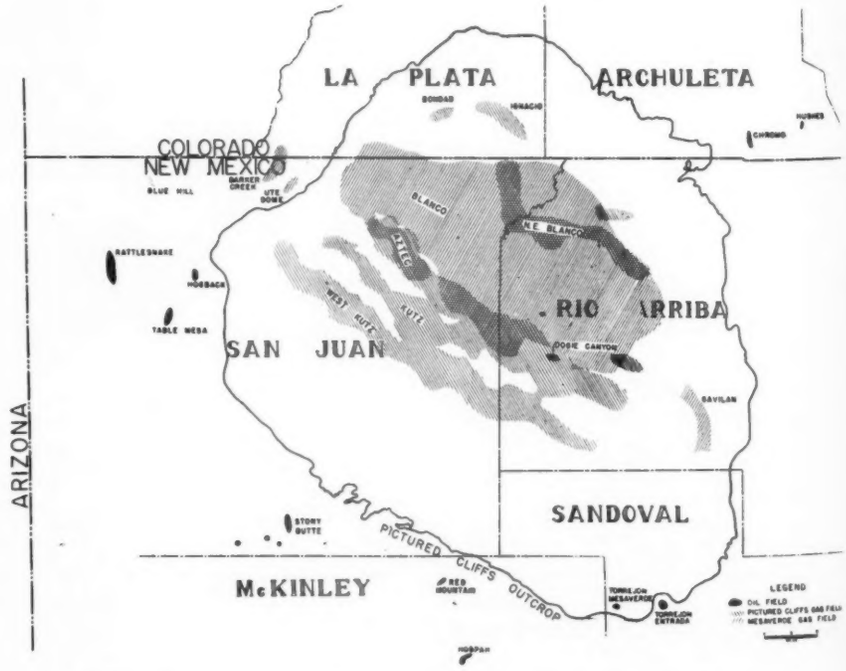


FIG. 1. Map showing outline of oil and gas fields in San Juan Basin.

*Consulting geologist, Denver, Colorado.

Further development and extensions of this field may focus more attention on the multiple sandstone zones of the Mancos.

Dakota Sandstone

Widely scattered wells completed in the Dakota sandstone for commercial production as well as a large per cent of the wells having shows of oil and gas are indications that future drilling and development will make a significant increase in the ultimate natural gas reserves of the San Juan Basin.

Present Dakota wells in the San Juan Basin are isolated one well fields only due to expense of drilling, and the focus on drilling the shallow Pictured Cliffs and Mesaverde wells to validate leases. Most of the wells completed in the Dakota have a relatively high reserve but a slow productive rate due to a low permeability. An increase in the present price of 12 cents per MCF for gas would encourage operators to drill for Dakota production.

Possibilities of Deeper Pay

The deeper pay possibilities based on wells on the outer edge of the basin that have drilled through these sediments are confined to the Morrison, Entrada formations and the Pennsylvanian, Mississippian and Devonian periods.

The Morrison is productive at Ignacio in La Plata County, Colorado. A significant show was recovered in the northwestern edge of the Dogie Canyon Field. Entrada production is confined to the Torrejon Entrada Field (Fig. 1) while the Pennsylvanian is confined to the northwestern portion of the basin at Barker Creek, Ute Dome, Hogback, Rattlesnake and Blue Hill. Although natural gas was recovered in the Mississippian and Devonian at Table Mesa, Hogback and Rattlesnake, the helium content was high with commercial possibilities being of minor significance.

Annual Production

There was a gradual increase in production of natural gas from 1948 to 1950 as a result of the increase in the local market, which was furnished by Southern Union Gas Company. After 1950 the approval of the El Paso Natural Gas Company's pipe line gave an additional outlet to the Pacific Coast. As is shown on Fig. 3, the increase in the sale of natural gas has been rapid, increasing from 14,391 MMCF in 1950 to 163,156 MMCF in 1954. The approval of the Pacific Northwest pipe line as well as the possibility of another El Paso pipe line being approved for the Pacific Coast should almost double the present market within the next two to three years.

Drilling Activity

A history of the active number of wells (Fig. 2) indicates irregularities with a gradual increase from 1946 to the present time. It will be noted that the graph represents the Four Corners area of which the San Juan Basin is a part. The graph is used as an index to the San Juan Basin due to the fact that approximately 95 per cent of the wells drilled were in the San Juan Basin. It will be noted that the slumps are a result of seasonal weather and controversies over pipe line outlets. The large increase in drilling from January 1 to July 1, 1955, is a result of lease terminations as well as the approval of the Pacific Northwest Pipeline.

The area outlined on Fig. 1 as proved gas fields is not fully developed with numerous inside locations to be drilled. These inside locations along with the reasonable amount of field extension will cause approximately 5000 additional wells to be drilled in the development of Pictured Cliffs and Mesaverde gas fields. Additional wells will be drilled in the development of the multiple sandstone stringer of the Mancos as well as the Dakota sandstone.

Conclusions

The San Juan Basin is developing into what may be the largest gas reserves in the country. Production is at a slow rate as a result of low permeability; however, the porosity and thickness of pay sections as well as the large areas of production indicate a high reserve with production lasting over a long period of time. Drilling is at a fast rate due to additional pipe line outlets as well as short term leases.

Inside locations yet to be drilled as well as extensions of present fields indicate a forced high development program for the next three years. New pay zones being discovered as well as deeper pay zones to be developed will cause continued development over a much longer period of time.

The natural gas market will be increased as a result of the approval of additional pipe lines to the Pacific Coast.

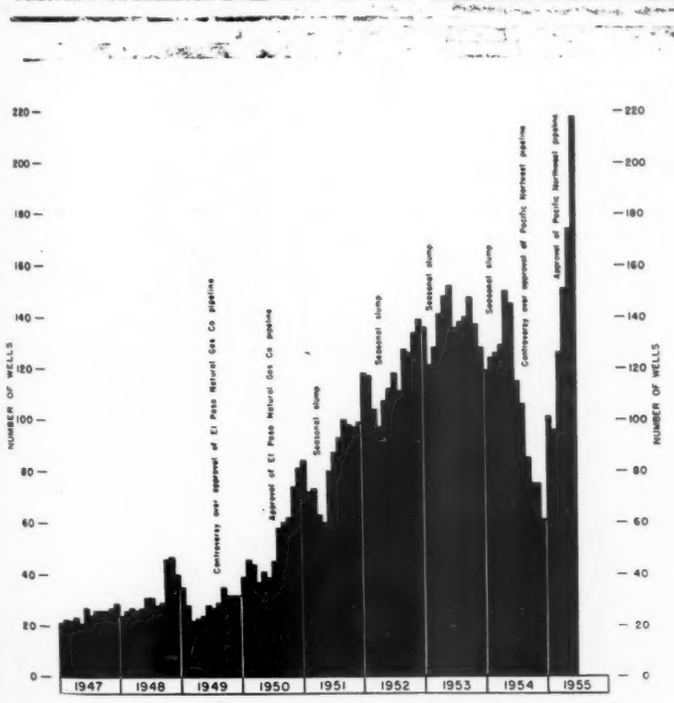


FIG. 2. Annual oil and gas production in the Four Corners area.

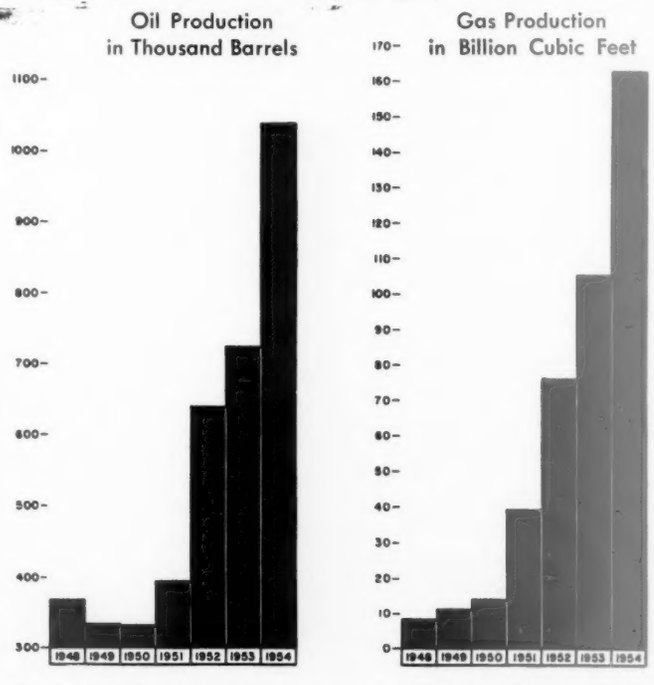


FIG. 3. Monthly average number active wells in Four Corners area.

AREAS OF PROMISE RECALLED

Midland Basin

James C. Watson

THE Midland Basin, a 140 by 60-mile northwest-southeast stretch of territory situated in the geographical center of West Texas' vast Permian Basin oil empire, during the past 12 months has held the key to the region's deep drilling operations.

An intensive deep drilling program has been going on in a number of areas of the Midland Basin for more than 3 years. During the last 6 months an average of approximately 30 deep drilling rigs have been kept busy in the Ellenburger trend of West Midland and East Ector counties.

Developments during the last year indicate, to many qualified observers, that this rate of deep drilling will probably continue—and possibly increase, for an indefinite period.

A practical oil operator—with more than 25 years of experience in the West Texas and Southeast New Mexico—recently remarked, "before all of the deep oil is found in the Midland Basin, I expect to see at least one deep well drilled for every square mile of territory in the Basin."

Now, he did not mean that there would be one deep well drilled on every square mile in the Midland Basin—but that—if you consider the Basin to be 140 by 60 miles—or a total of 8400 square miles of area—that before the full producing, or non-producing ability of the area is determined—it would require the drilling of at least 8400 deep wells.

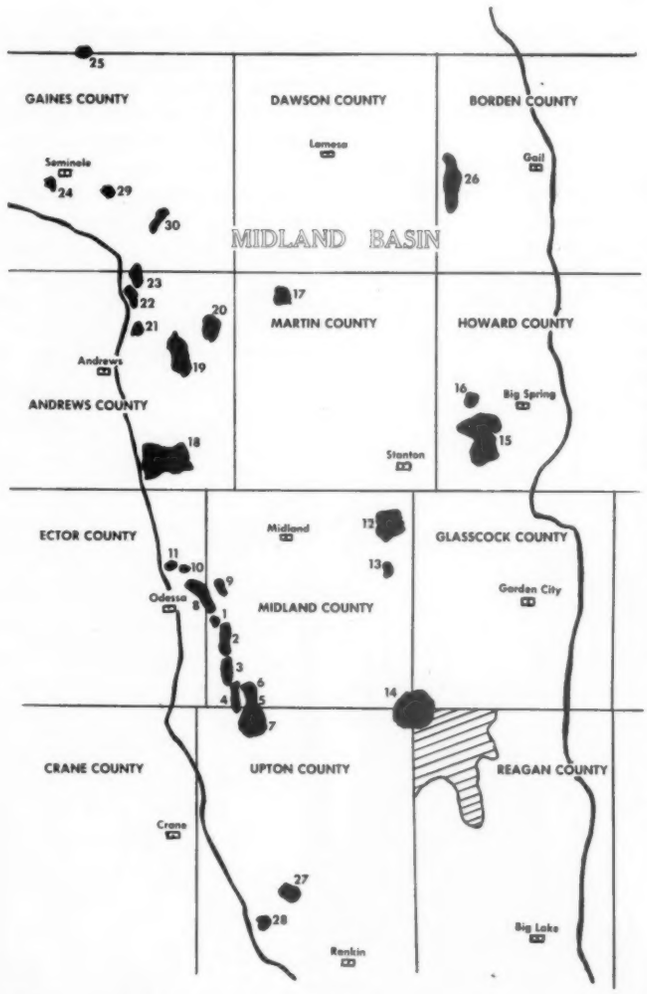
The current development program in the Midland Basin and the heavy concentration of deep drilling rigs in the area is due to an almost 100 per cent successful completion rate during the last three years on deep wildcats and stepout projects.

Deep activity in this district since July 1954, has uncovered the area's most important new oil reservoir, and probably the most important found in Texas during the same period.

Although more than 30 oil discoveries have been claimed by the area during the past 12 months, by far the most important development has been the joining together of the scattered pools in the Midland Ellenburger trend which reaches from East-Central Ector County to the northwest corner of Upton County.

Although the Headlee (multipay) pool, near the north end of the 25-mile long trend, and the Sweetie Peck (multipay) field at the extreme south end were found in 1952 and 1949 respectively, the spark that ignited the present stepped-up activity in the region was the leasing of the 20,000-acre Dora Roberts Ranch by Forest Oil Corporation and Cities Production Corporation.

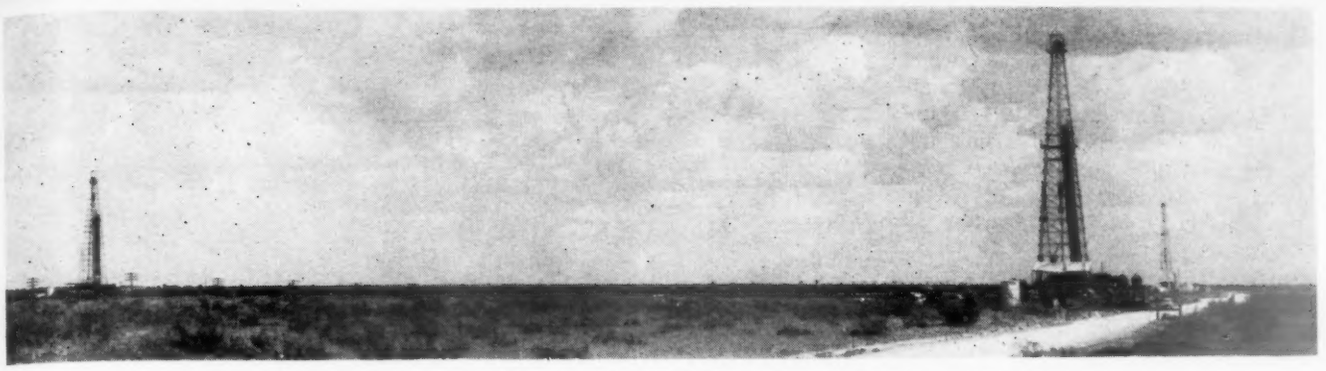
Even before the lease deal was announced, a sprinkling of activity along



Fields:

1. Dora Roberts (multipay)
2. Virey (multipay)
3. Warsan (multipay)
4. Sweetie Peck (multipay)
5. Pegasus (multipay)
6. Pegasus (San Andres)
7. Pegasus (Spraberry)
8. Headlee
9. Hallanan (Strawn)
10. Ratliff (Ellen)
11. Barrow (Ellen)
12. Germania Grayburg
13. Tex-Harvey Grayburg
14. Spraberry (Clear Fork)
15. Moore (San Andres)
16. Varel (San Andres)
17. Breedlove (Devonian)
18. Midland Farms (multipay)
19. Magutex (multipay)
20. Prichard (multipay)
21. East Means (Strawn)
22. McFarland (multipay)
23. Nolley (multipay)
24. Southwest Seminole (Devonian)
25. West Seagraves (Devonian)
26. Jo-Mill (Spraberry)
27. Amacker-Tippett (multipay)
28. King Mountain (Ellenburger)
29. Wescott (Strawn)
30. Amrow (Devonian)

Outline map of the Midland Basin showing only those areas of importance and which were outstanding during the last 12 months. Cross-hatched area indicates active Spraberry sand development.



Three rotaries dot the sandy flatlands of Midland County to extend the South Headlee Field.

the east side of the ranch opened the Warsan and Virey (Ellenburger) pools. These new fields brought in a few new rigs and operators.

It was not until September 1954, however, when British-American Oil Producing Company and others completed No. 1 Roy Parks, Jr. Estate, two miles south of the Headlee field, as a prolific Ellenburger well, that activity in the deep trend took on boom proportions.

In October 1954, the first Dora Roberts well was completed by Forest and Cities Production. It was No. 1-C-4 Dora Roberts, on the west side of the Warsan field, completed for a 24-hour flowing potential of 3205 bbls of oil. Next important Ellenburger find was same operators' No. 1-B-1 Roberts, which opened the Dora Roberts field. After these important strikes, the Midland Basin operators went after the deep oil in earnest.

It takes only a quick look at a map of the area to realize the impact of the success of the trend's deep program. Although not more than 35 rigs could be found drilling in the long, narrow strip at any one time, the 25-mile long stretch of scattered pools virtually have been joined during the past 7 months.

The widest gap is between the Virey and Warsan fields, and it is less than two miles wide. No dry holes have been drilled between the two pools.

Not only have the Ellenburger wells been completed for prolific production, but in addition, the trend has come up with several other good pays from the upper formations. For example, the Dora Roberts field, an area between the Headlee (multipay) and Virey (multipay) fields, has four proved producing zones; Bend lime, Strawn lime, Devonian and Ellenburger. And this pool is only eight months old.

These pays also are producing in almost every area of the trend. The fourth pay, Bend, was discovered less than two months ago in the Headlee area, which already had Ellenburger, Strawn and Devonian production. A fifth pay, Fusselman, was added to the area with completion of Cities Production Corporation No. 1 Parks.

Other important developments in the region include the extending north of the trend by The Texas Company's No. 1 Ratliff, discovery well of the Ratliff (Ellenburger) field, and the opening of the Barrow (Ellenburger) pool, further to the northwest by Humble Oil and Refining Company. At present, there are about 30 rigs scattered along the narrow strip in Midland and Ector counties.

Following the West Midland area in importance during the past 12 months was the opening of 2 new Devonian fields in the north end of the Midland Basin, and finding of a deep Ellenburger oil field in Southwest Upton County.

The Ellenburger strike in Upton County was completed by Humble, which found prolific production at No. 1-D Barnett. The King Mountain field strike was finaled for a 24-hour flowing potential of 1615.24 bbl of 54.8-gravity oil from pay at 11,775-11,840 ft. Several rigs now are seeking production in the same zone. The field's discovery, also developed flowing oil in the Devonian, and an outpost to the strike has indicated Clear Fork production.

Closest comparable Ellenburger production is in the Amacker-Tippett (multipay) area five miles to the northeast. This field has been the "hottest" Upton County section during the past year. The pool has production from Ellenburger, Strawn, Cisco and Wolfcamp, and each of the pays is now undergoing a heavy development program.

Humble also opened the Southwest Seminole (Devonian) field in central Gaines County. The well, No. 1-B Riley, completed March 31, for daily flowing potential of 282.82 bbl of 35.4-gravity oil, is one of 2 important Devonian strikes during the past 6 months in that county.

The other, completed 5 days after Humble completed No 1-B Riley, is Anderson-Prichard Oil Corporation and others No. 1 Webb. This project, 18 miles north of No. 1-B Riley, was completed for a daily flow of 607 bbl of oil from pay at 13,028-13,086 ft. The Humble discovery was finaled at 11,568-588 ft.

No. 1 Webb was named discovery well of the West Seagraves (Devonian) district. The high potential, free of water, has caused Anderson-Prichard to start three other projects in the area, one of them being in the completion stage. This well, No. 1 Powell, flowed 120 bbl of oil hourly on a drillstem test of the Devonian.

Getting away from deep developments, two shallow areas have been opened to production during the past three months, and have good chances of becoming good Midland Basin producers.

One of these is in the huge Spraberry trend area field of Midland, Glasscock, Reagan and Upton counties. Rowan Oil Company plugged back in an old Spraberry well in Northwest Reagan County and completed the Trend's first Clear Fork oiler. Since that time, four others have been completed and more are on the way.

Two of the wells extended production into southwest Glasscock County, and the other spread the pay into northeast Upton County. Attempts were being made to develop production from the same Clear Fork pay in Midland County. Although these wells average only 10 ft of effective pay, potentials have ranged from 200 to 400 bbl of oil daily.

What effect this new producing horizon will have on the much discussed Spraberry area is yet to be seen. Some operators believe the Clear Fork will have a short life due to thinness of the pay, while others are of the opinion the production will last long enough for a profit to be realized.

At present, about 16 square miles of the Spraberry's Four Corners area has been termed productive from the Clear Fork. How much more of it can be produced can only be determined by testing.

The other shallow area, 60 miles northwest of the Spraberry's Clear

XUM

Areas of Promise

Fork pay, is the Queen sand and Grayburg areas in the East Andrews portion of the Midland Basin. B. L. McFarland, drilling contractor, No. 1-3 University found the Midland Basin's first Queen sand oil, and completed from that zone to the McFarland field. One mile north of this strike, Lawton Oil Corporation opened the field's Grayburg pay zone with completion of No. 1-B F. A. Bird, which also was completed to extend Queen sand production.

Less than two months old, this area already is scene of stepped-up activity. Recent extenders to the multipay pool assure a comparatively large reservoir from standpoint of acreage.

An old shallow field, the Moore in West Howard County, took over much of the year's shallow activity in the Midland Basin. During the 8-month period from August 1, 1954, to March 31, 1955, 45 new wells were added to the field, and many of the old producers in the pool were worked over.

For several years, activity in this area was at a standstill, but due to new completion techniques and more particularly to fracture method of loosening up oil bearing formations, the Moore field came to life with a bang. Although activity has subsided during the last 3 months, 7 or 8 rigs continually are working in the area, which now has 119 producers.

Slightly northwest of the Moore area, another San Andres field, the Varel, has been drawing much attention. This shallow pool is working about the same number of rigs as the larger Moore field.

Another section of the Spraberry that has seen revived activity during the past 12 months is the portion in Northeast Midland County. There, in the Germania field and the old Tex-Harvey portion of the sand area, operators have been trying to spread the Grayburg pay which was found in 1952. After the discovery well was completed that year, only 3 more oilers were completed until late in 1954. During the past 8 months, 12 more wells were completed from the Grayburg, and several other attempts to extend production failed

Extensive search for Spraberry oil in West Borden County during the past year has lead to the expansion of the Jo-Mill field in all directions. Activity in this area included the re-entering of several Pennsylvanian failures, which were either replugged or completed as producers from the Spraberry sand.

Outside of Midland, Dawson and Upton counties, the only successful deep activity of note has been the opening of good Ellenburger production just north of the already established Wemac (Ellenburger) field of Andrews County. Continental Oil Company extended the field one-half mile north with completion of No. 1 McCollum and Means for a prolific flowing potential of 3798 bbl of oil.

Forest Oil Corporation and Cities Service Production Company's No. 1-42 Fee, being drilled on the famous Dora Roberts Ranch in Midland County, Texas.

Further development in this area probably will be only at a normal, routine speed, because the acreage is rather closely held.

A well drilled by Gulf Oil Corporation in North Midland County, 2½ miles north of Midland, drew much attention when it found shows for Waddell production, and later completed as an Ellenburger discovery. This oiler, Gulf No. 1-L Scharbauer Land and Cattle Company, reported a small potential, 60 bbl of oil, but closest other Ellenburger production is 18 miles to the northwest in the Midland Farms field of Southeast Andrews County, and about the same distance to the southwest in the Headlee pool. At present, only activity in the field, which was named Ruth Scharbauer, is an offset being drilled by Gulf.

Other Midland Basin development during the past year was opening of flowing Spraberry production in the Pegasus multipay field by Sharples Oil Corporation No. 5-B TXL. Second completed in the Pegasus district from the Spraberry, the well had an initial daily flow of 756 bbl of oil. It is the only flowing Spraberry well in the field, and is in Upton County.

Also in the same field, a steady San Andres pay development program has been underway in the Midland portion.

Another highlight of the past 12 months has been the continued Spraberry sand activity in Northwest Reagan County, where an average of 14 rigs have been drilling. Operators have found that Spraberry wells in this area have a much better productive life than in others parts of the huge trend.

One of the most important phases of the Midland Basin oil picture during the past year has been the steady development and extending of already proved fields. In Andrews County, fields such as Wemac (Ellenburger and Devonian), Magutex (Ellenburger and Devonian), Nolley (Wolfcamp and Queen), East Means (Strawn), and Midland Farms, which has Ellenburger, Fusselman, Wolfcamp and Grayburg production, have been very active during past 12 months.

Producing limits have not been established for these fields, which are among Andrews County's best shallow and deep zones. Both inside and outside development are due to be carried on in these areas for several more years.

In Midland County, outside the Ellenburger trend, the Pegasus and Hallanan fields have been, and still are active.

Extending operations were carried on during the last 12 months in the Amrow (Devonian), Toby Jo (Wolfcamp), and Wescott (Strawn) fields of Gaines County.

The Amrow pool, one of the most important deep areas uncovered during the past three years, not only has turned out to be a good producer, but operators have learned much about Devonian geology from this field. Its producing limits are far from being defined.

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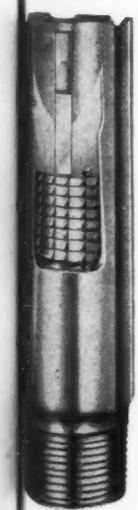

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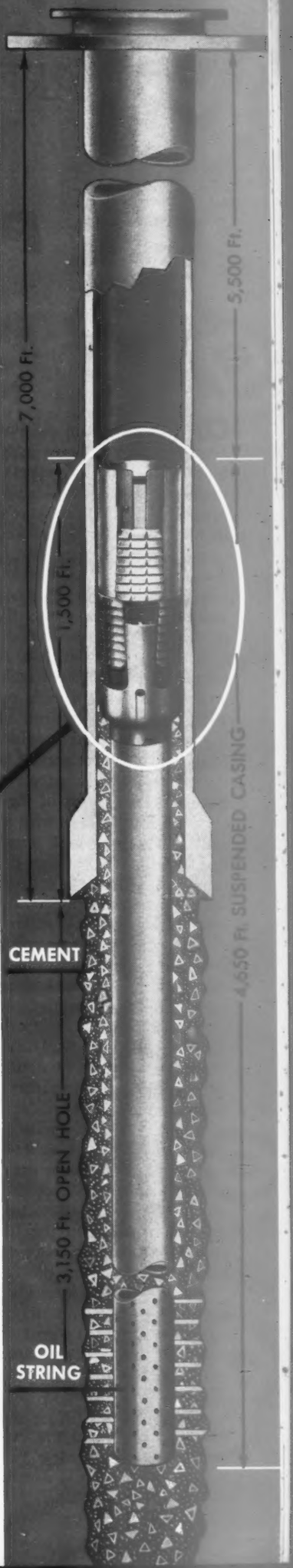

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AREAS OF PROMISE RECALLED

Powder River Basin

W.E. West, Jr.*

DISCOVERIES in the Powder River Basin since 1952 have added substantially to the reserve expectancy of this important producing area. Two new producing formations have been added to what was already an impsosing list of pay zones. No less than 15 potential pays, ranging in age from Pennsylvanian to Upper Cretaceous, now await the operator who drills a wildcat in the Basin.

The greatest addition to reserves has come from discoveries and extensions adjacent to fields already producing in 1952. These successes are no less exciting because of their proximity to older fields and all have served to stimulate the search for the elusive Powder River Basin oil field. Most of the recent discoveries are involved with stratigraphically-trapped oil and it can only be deduced that therein lies the future of the Basin. The search for structure goes on, however, as evidenced by the considerable geophysical activity.

The cost of exploring for oil is greater (a condition certainly not exclusive to the Powder River Basin) and will undoubtedly continue to rise since future exploration will often require multiple "strat" holes. The existing well control is, with the exception of one or two localities, extremely inadequate and, because of this lack of sub-surface information, the ultimate potential of the Basin will not be realized for many years. The forecast for the future then is one of slow but steady progress, with each wildcat, whether successful or dry, contributing to the fund of subsurface knowledge necessary to the successful search for oil.

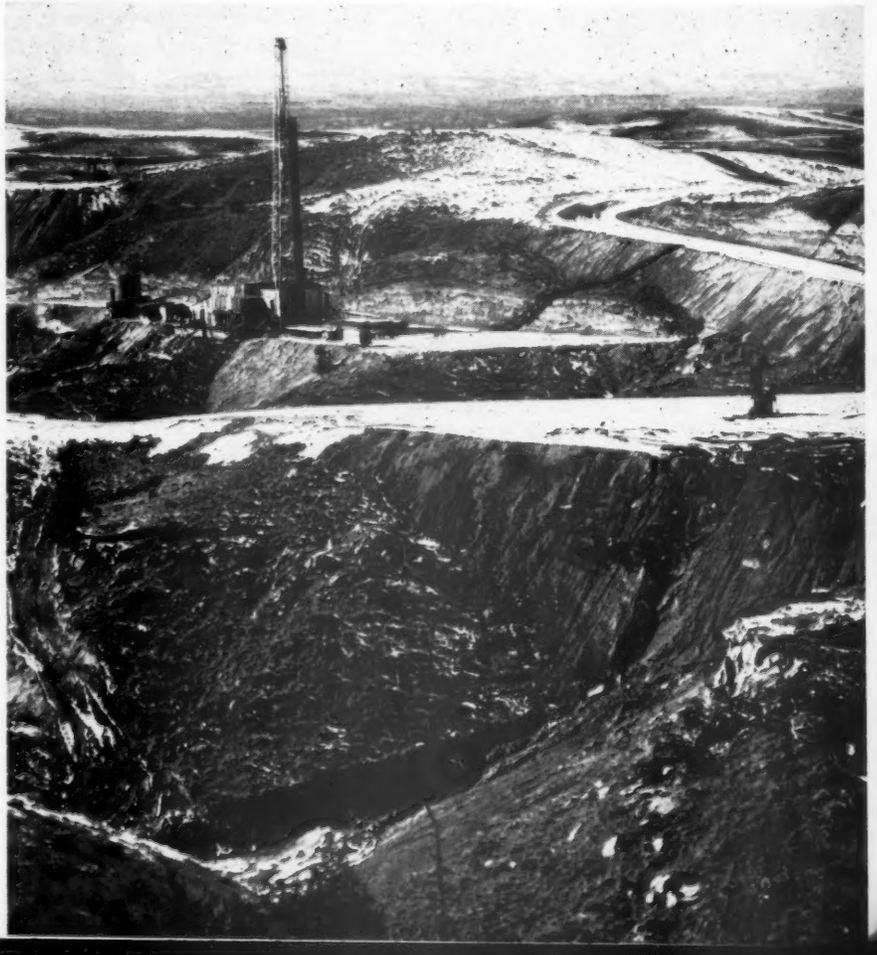
Rising costs and inadequate data will not prove deterrents to exploration, however, for the Powder River Basin is one of the favorable areas where it is still possible to find a big oil field.

The future of any oil province must be evaluated in terms of past exploration. In the case of the Powder River Basin, this seems especially true and the discoveries and developments of the past three years are considered typical of what may be expected in the future.

In mid-1952 only the first several wells had been drilled in the **Ash Creek Field** (A on map). The productive area now embraces almost 1000 acres. The **South Ash Creek Field,** one and one-half miles south, was discovered in 1954 and rapid development drilling has outlined a productive area equal in extent to that of Ash Creek. Both fields are fault traps in the Shannon sand (Upper Cretaceous). Cheap drilling costs and good reservoir conditions make the fields highly profitable. Exploration has accelerated greatly in this northwest portion of the Basin despite numerous dry holes. A major problem concerns the difficulty of obtaining reliable seismic work.

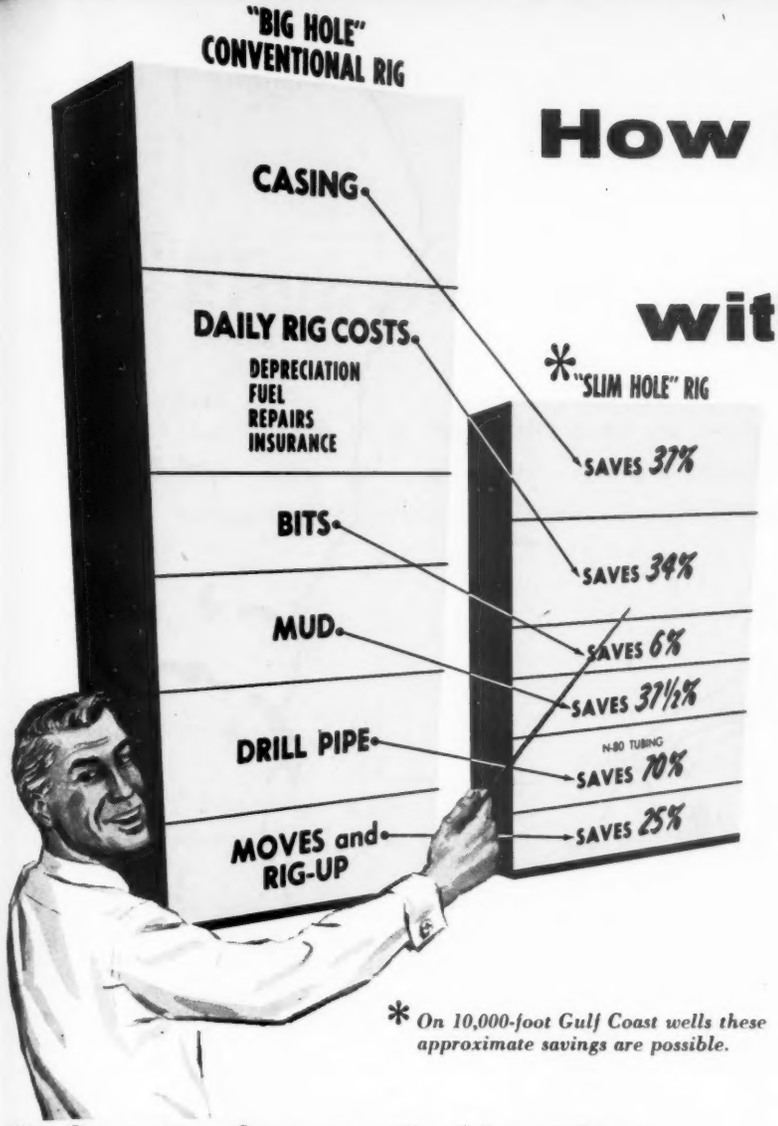
The **North Tisdale Field** (B on map) is one of the perplexing fields for which the Powder River Basin is noted. It is situated down the north plunge of the prominent Tisdale anticline, on which has been drilled some thirty unsuccessful tests. The north Tisdale field produces from the Lakota (Lower Cretaceous) and Curtis (Triassic) at depths of 300 ft and 900 ft respectively. The field is several hundred feet lower than the culmination of the Tisdale anti-

Rig working in Meadow Creek field of Powder River Basin.



*Consulting geologist, Casper, Wyoming.

How to cut costs with SLIM HOLE drilling . . .



* *On 10,000-foot Gulf Coast wells these approximate savings are possible.*

One practical approach to reducing exploration and development costs is to drill a smaller than conventional hole using less expensive equipment to effect a reduction in daily operating costs.

Mr. Operator—*here are the big savings*

- **SMALLER CASING...**
  The trend toward smaller diameter pipe will effect substantial savings over conventional casing sizes.
- **LOWER OPERATING COSTS...**
  A Slim Hole rig has lower capital investment, depreciation, insurance, taxes, maintenance, and will require much less fuel than a conventional "big" rig. This reduction of daily operating costs is reflected in logging, completion, round trip, and drilling time charges.
- **CHEAPER BITS...**
  Bearings and tooth structure of today's Slim Hole bit is more efficient than those of a year ago. In some areas the Slim Hole bit performance does not compare with the conventional sizes, but because of their lower cost, savings are still effected.
- **LESS DRILLING MUD...**
  The smaller hole will result in smaller mud bills and smaller mud pits.
- **SMALLER DRILL PIPE...**
  It is often practical to use cheaper, small diameter pipe having a low depreciation. If pressures are inadequate, larger diameter, but cheaper tubing grades can be used and will result in less pressure losses.
- **LOW-COST MOVES...**
  Slim Hole rigs require less rig-up time, fewer loads, and cheaper site preparation.

Present Well Costs Too High!

Deeper drilling depths continue with resultant disproportionate rise in drilling costs. This kills the economic incentive to drill new wells.

Oil companies are searching for ways to reduce drilling costs so they may continue to drill the growing number of wells necessary to maintain U. S. producing capacity. Slim Hole is one answer.

Only one well in nine drilled in search of new oil finds production. Even in development drilling where nearly 50,000 wells are drilled annually, almost 40% are dry holes. In many areas, Slim Hole drilling will mean more wells for the same money.

Don't Go Into Slim Hole Drilling "Blind"

Let us show you how Cardwell equipment can cut your drilling costs... Your copy of "Slim Hole Drilling Facts" will soon be off the press. Write Philip L. McLaughlin, former Drilling Editor of *World Oil*, and now Head of Drilling Research, Cardwell Manufacturing Company, Inc., Wichita, Kansas, for your free copy.

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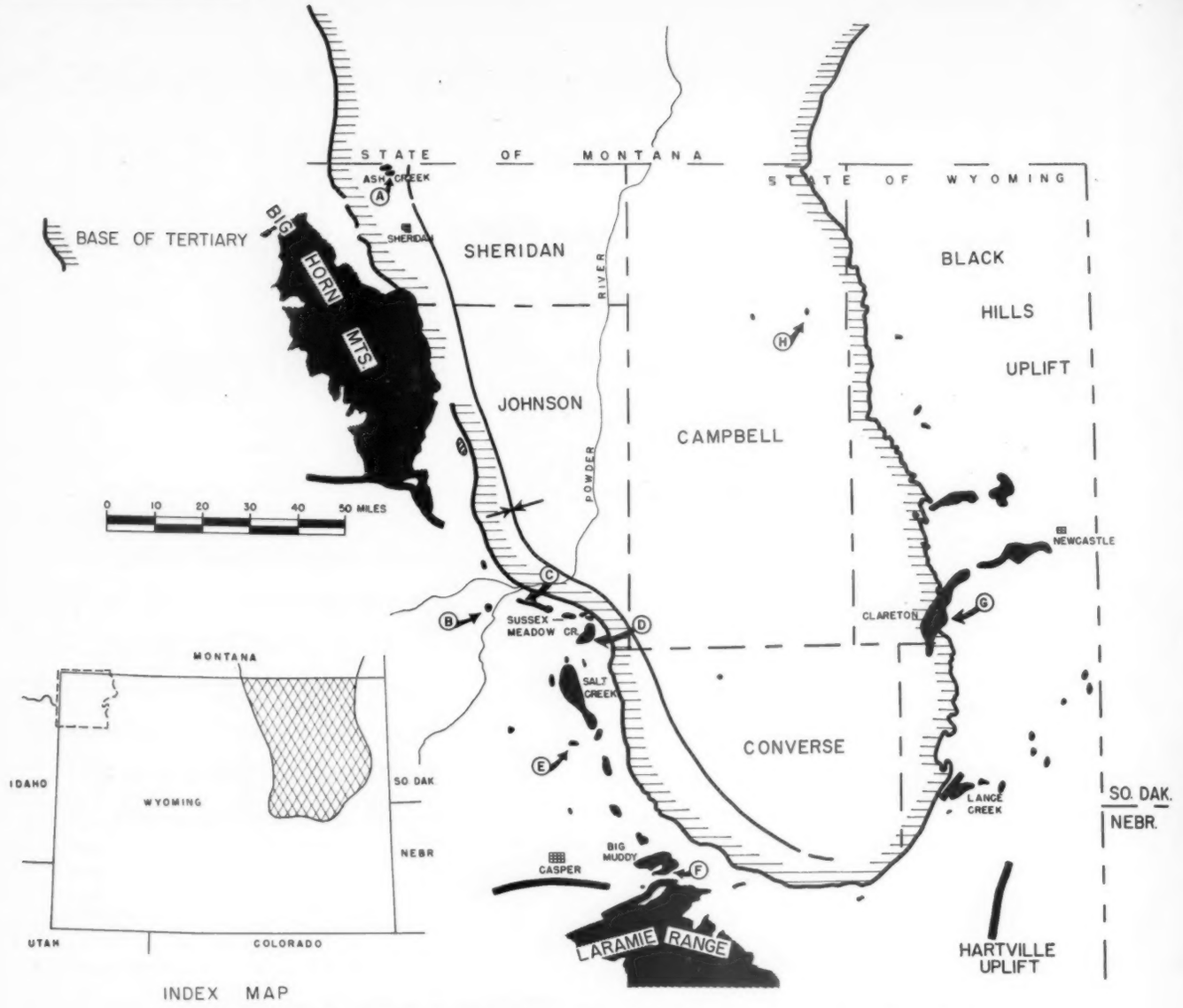


Map of Powder River Basin in northeastern Wyoming. It reaches into southeastern Montana.

cline where the Curtis is water-bearing and the Lakota is eroded away. In the absence of a structural trap, the Lakota oil is best explained by stratigraphic conditions and the Curtis as a hydrodynamic accumulation. The field was discovered in late 1952, marking the first Curtis production in the Powder River Basin.

The **West Sussex-Dugout Creek** productive area (C on map) has been extended 4 miles west since 1952. The productive Shannon sand occurs at depths ranging from 1900 to 3500 ft and the oil is trapped in a complicated fault system. In 1955 Tensleep (Pennsylvanian) discovery is expected to increase reserves substantially.

Tensleep development drilling in **Sussex-Meadow Creek** (D on map) has established that formation as the single most important reservoir in a highly-productive area which boasts 7 other pay horizons. Production is controlled by structure. Individual wells have encountered as much as 500 ft of water-free oil column in the Tensleep and underlying Amsden. At this date, development drilling is still underway.

The **Burke ranch** discovery (E on map) is especially significant since the field produces from the Dakota sand in an area where that formation was believed to have inadequate porosity and permeability to support good production. The stratigraphic discovery opens up a large prospective area, though the problem of locating permeable Dakota sand can be solved only by drilling wells.

In 1952 **South Glenrock** (F on map) was in the middle stages of development. The field has since been revealed as one whose ultimate recovery will exceed 50 million barrels. Production is stratigraphically controlled from the Dakota and Muddy sands. Today, five years after discovery, drilling continues in the Southwest portion of the field where Muddy production is found in an extremely meandering pattern of sand development. The productive area is continually being extended, with the hazards of drilling for a frequently narrow band of productive sand being offset by the prospect of excellent wells having up to 35 ft of pay.

The biggest drilling "boom" of the past three years occurred in the **Clareton-Black Thunder-Cheyenne River** (G on map) vicinity where stratigraphic Newcastle sand production has been extended south and west to include an area some 30 miles long by 2 to 5 miles wide. Many individual wells and properties are questionably economic but the entire area comprises a major reserve of high gravity oil.

Mitchell Creek (H on map) a non-commercial Pennsylvanian discovery of 1953 was none-the-less significant since it renewed interest in the pre-cretaceous possibilities in the vast and little-explored northeast portion of the basin. * * *

Elements of Water Injection

The second in a series designed to bridge the gap between theoretical considerations and actual field practices. General topics discussed are:

- **the flooding process**
- **oil saturation**
- **relative permeability**
- **crude characteristics**

J. Randolph Buck
Consultant, Dallas, Texas

APART from the geological considerations in the selection of a flood property are the engineering matters that relate principally to the determination of the quantity of oil in place, physical characteristics of the crude, and the practical field-type of information that ties in with future recovery possibilities. To appreciate the significance of the engineering factors, it is well to consider just what processes actually take place within the sand during the time between the start and completion of the flood.

Saturation Conditions. A depleted sand has porosity that is occupied entirely by oil, water, and gas. The fraction of the total pore space that is occupied by any one of these fluids is termed the saturation of that fluid. For example, one might encounter:

oil saturation	0.50
water saturation	0.30
gas saturation	0.20

In all cases, the sum of the three saturations must equal unity, the total pore space.

When water is injected into this sand, oil is forced away from the injection well. Two new additional zones of saturation are created. Consider first the volume of sand nearest the injection point. Here, the saturation might become:

oil	0.35
water	0.55
gas	0.10

Note that the oil and gas saturations decreased while the water saturation increased. This situation describes what has happened in those portions of the sand where water has already done its work. Now look at the sand some distance away from the injection well into which the displaced oil and gas has moved. Here the saturations might become:

oil	0.60
water	0.30
gas	0.10

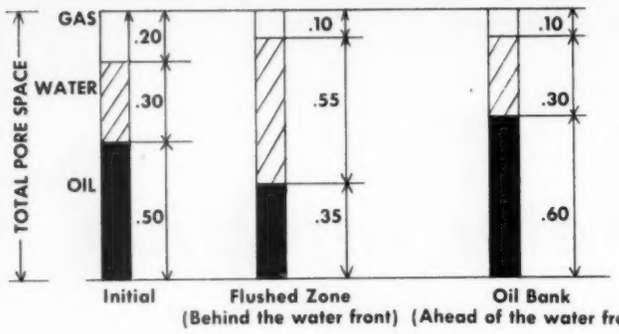
Note that the oil saturation has increased, the gas saturation decreased, and the water remained constant. This region is referred to as the oil "bank" or "front." As water is injected continuously, the oil bank accumulates and advances toward the producing wells. Since gas is the easiest of the three fluids to flow, it is the first to reach the producing wells. Gas may bring along with it some oil to show the first increases in oil production as the result of the water injection. When the oil front reaches the producing well, oil production enters upon a period of peak rate. When water behind the oil finally reaches the producing well, it is termed the "water breakthrough" and is indicative of declining oil production rates thereafter. A well producing injected water along with oil is described as being in the "subordinate stage." How effectively this ideal process can be carried out in practice depends on the saturation relationships, properties of the fluids, and performance characteristics of the sand.

EXCLUSIVE

Oil Saturation

Primary Drive. The presence of adequate oil in place at the start of a flood is of paramount importance. The amount left in the ground after primary production is a measure of the inefficiency of the producing mechanism that previously had been operative. The least efficient is the solution-gas drive mechanism. The most efficient is gravity drainage. Gas cap expansion and water drive fall within this spread. Reservoirs already depleted by natural water drive can be eliminated as prospects for additional recovery by water injection using the standardized methods of the past. Here again, an eye must be kept on current and future innovations that may later re-open this class of reservoir to new possibilities. In most cases, gravity drainage fields can also be omitted from further consideration as waterflood locations. No producing mechanism can improve on one inherently more efficient than itself. Down-dip areas of old gas-cap fields are favorable as are also the solution-gas drive fields. Since these latter two are the least efficient in terms of primary recovery, the probability is greater that relatively more oil will still remain in the reservoir after primary depletion. This implies a favorably high initial oil-saturation value that can be evaluated either from core analysis data or calculations based on cumulative production and the total original oil in place in the reservoir.

Minimum Saturation. A high, initial oil saturation does not automatically



Graphic illustration of saturation conditions within a reservoir at various stages of flooding.

assure high flood recovery, but it certainly can help. If this factor is on the low side, it definitely is detrimental. For use as a yardstick, it is suggested that oil saturations below 0.45 be studied with special care. Experience has shown that below 0.40, floods do not recover in the field as much as was calculated. It would seem that 0.35 would represent a minimum value below which flooding rarely should, if ever, be undertaken. Significance of the initial oil saturation is influenced heavily by the water saturation value.

Interstitial Water. Water saturation should be neither excessively high nor low. In all cases, it should be less than the oil saturation. Where water saturation exceeds that of oil, it is improbable that a bank stage can ever be developed. Injected water merely displaces formation water with the result that increased water rather than oil production is felt at the producing wells. Connate water values on the order of 40 to 45 per cent would be at the upper limit of the acceptable range. While no lower limit to the connate water can be set, the point is made that flooding advantage cannot be taken of the additional oil in place implied by low water saturation. Compensating losses arising out of wetting the sand surfaces by oil tend to neutralize what would otherwise appear to be an advantage. While 20 to 30 per cent interstitial water is generally ideal, the broader range from 10 to 40 per cent is worthy of full consideration. At the higher water and total liquid saturations, the injection of gas rather than water offers more promise for inducing additional oil recovery.

Relative Permeability

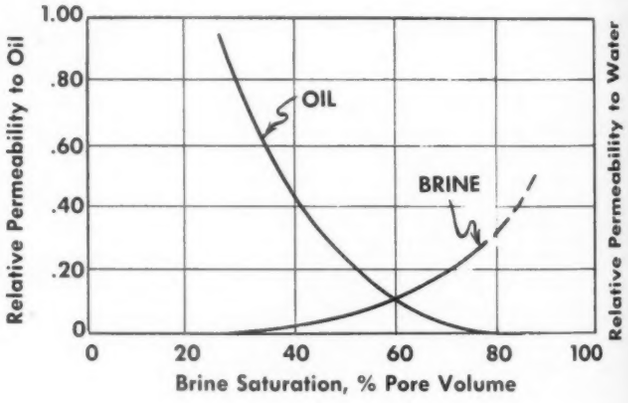
The problem of water saturation has been brought into focus by means of the relative permeability relationships. Relative permeability refers to the ease with which either oil, water, or gas can flow through the sand under given conditions of liquid saturation in the sand. Where water saturation is high, permeability to water is also high on the relative scale. The same holds true for oil or gas. During the life of a flood, saturation of the fluids at any point in the reservoir is constantly changing. Accordingly, the ability of each of the fluids at that point to flow is changing. At the extremes, when oil saturation is high, permeability to water is low, so oil is the flowing fluid. When water saturation becomes high, permeability to oil vanishes, leaving water as the flowing fluid. This concept explains much of the performance as observed in flooding work. Actually, it is the ratio of the relative permeability to water over the relative permeability to oil at the given conditions of saturation that best defines a particular situation. It is through the knowledge and application of relative permeability relationships that predictions of future performance can be calculated in detail.

Characteristics of the Crude

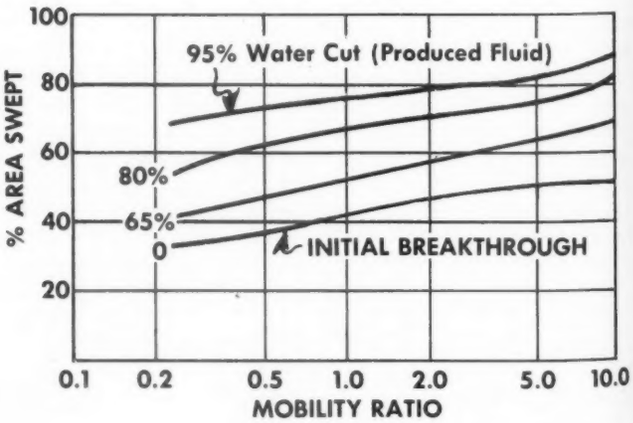
Oil Gravity. Gravity of the crude oil to be flooded is not so much a factor in itself as it has been an indicator of other more important properties. The medium gravity crudes (in degrees API) include the lighter and generally less viscous oils that are more easily displaced by the injected water. Low gravity is associated with unfavorably low viscosity. In this regard, it is of interest to note that flooding has been undertaken with at least technical success below 20 deg API. High gravity is related to high shrinkage with resultant low oil in place in terms of stock tank barrels. The urgency increases for primary pressure maintenance rather than secondary recovery for the high gravity crudes. Explanation for this is that the water injected can flush out oil down only to some reasonable value of oil saturation, and it is preferable from the recovery point of view to have this residual oil saturation in terms of oil still expanded with solution gas than oil that has already undergone the shrinkage process.

Viscosity. Viscosity of oil in the reservoir is of great importance since it influences not only the quantity of oil to be recovered but also the manner in which it is produced. Important

Typical relative permeability curves. Note that permeability to oil decreases as the water saturation in the pore space increases.



Type curves indicating that for a given water cut of the produced fluid, more area will have been swept by the injected water for the cases of higher mobility ratios.



though it is, viscosity is not so critical as the relative permeability ratio. This point is understood when one considers that doubling the oil viscosity doubles the fraction of water flowing in the sand, while reducing the oil saturation by five per cent might also double the fraction of water flowing. As a generalization, low viscosity fluids are distinctly preferred.

This argument is tempered, however, by the fact that it really is the ratio of the viscosity of oil in the reservoir to the viscosity of water in the reservoir that controls the flooding mechanism. By virtue of this ratio, a 10 centipoise oil at a depth of 2000 ft should perform the same as a 5 centipoise oil at 9000 feet because of the often-ignored variation in the viscosity of water with temperature.

If the ratio of viscosities, oil to water, is less than 30, there is reasonable expectation that the injected water is capable of flushing out the oil down to some reasonable value of residual oil saturation. Above this arbitrary ratio, one might expect more channeling of water than a true frontal advance. Low viscosity ratios contribute toward low residual oil saturations as a result of flooding. High viscosity ratios demand more thorough examination of initial saturation conditions to assure that there will be ample recovery despite relatively high final oil saturation in the sand.

a controlling factor is demonstrated in

Mobility. The utility of viscosity as the development of ideas relating to the mobility of various fluids in the reservoir. The mobility of a given fluid is defined as the ratio of the permeability to that particular fluid over the viscosity of the same fluid. Ahead of the oil bank, oil is the flowing fluid, while behind the oil front, water is the flowing fluid. Each possesses a different mobility. The ratio of the mobilities ahead of and behind the front is known as the mobility ratio.

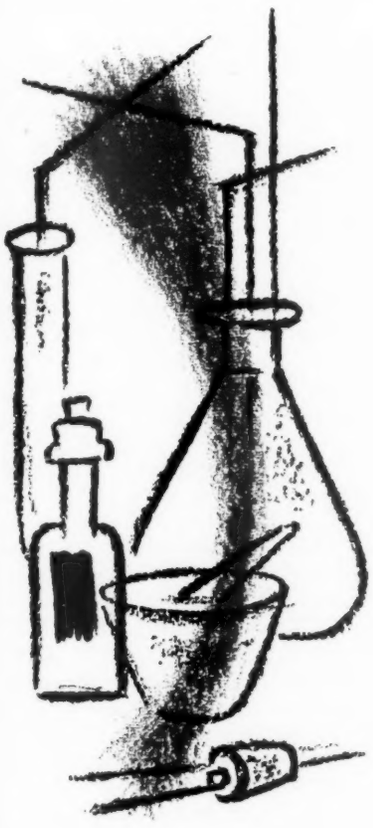
Mobility ratio has been studied particularly with respect to aerial sweepout efficiency and oil recovery both at the time of first water breakthrough and ultimate recovery.

Outstanding among the findings is that a 100-fold change in the mobility ratio can account for approximately a 50 per cent change in oil recovery at the time of water breakthrough. This wide range in oil recoveries is due to variations in sweep efficiency, which in turn is a function of mobility ratio. While in the majority of field operations a satisfactory sweep can be achieved by the continued injection of water after breakthrough, high mobility ratio floods are much more attractive economically since they can attain a given sweep with less water injected. Mobility ratio can be considered to be on the high side when the ratio of the permeability to oil ahead of the front over the permeability to water behind the front exceeds the oil-water viscosity ratio. In summary of the whole viscosity problem, a flood prospect should be condemned on the basis of oil viscosity only after viscosity has been reviewed from the viscosity ratio and mobility ratio standpoints.

Chemical Composition. The chemical composition of the reservoir oil and gas should not be passed over without attention. Sour crudes and sour gas set the stage for mechanical-equipment corrosion problems in the years to come. The tendency for a crude to deposit paraffin, asphaltines, or other residues in the sand is of definite concern to an operator. The injection of cold water into a sand containing oil that precipitates wax at plus 70 F could be catastrophic. While preheating the injection water might be the answer, the adverse effect of heating on water viscosity may not be ignored.

To Be Continued

Next in this series will discuss additional engineering factors in property selection. These will be: field observations, coring, and laboratory investigations. * * *



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Even though most of our customers never see our lab at Breckenridge, its facilities and technicians are as much a part of our service as our fleet of field units.

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FIG. 1. Location of four producing fields in Cuba are shown above with the known asphaltic and gas seeps as indicated.

A Potentially Important Source of Oil, This Island in the Caribbean Continues To Be An Enigma

Evidence and Occurrence of Oil Seepages in Cuba

Florent H. Bailly

FEW are the places in the world where there are as many tar, oil, and gas seeps with so little production of oil as in Cuba. Evidences for the presence of oil abound and have been reported from one end of the island to the other since the time Columbus's vessels put into Puerto Padre to caulk their seams with Maniabon tar.

Many students of geology and its various sciences have contributed to the literature on the geology of Cuba. The perusal of this material leaves the reader with the unmistakable impression that the geology of the island is extremely complex. In 1948, when the writer first visited Cuba, not only was the widespread evidence for the presence of oil a striking phenomenon, but the nature of the occurrences, the type of formation in which the evidence predominated was just as striking.

Most, if not all of the reported occurrences of hydrocarbons and all the producing areas of Cuba were in close proximity to, or directly associated with, serpentines or unaltered basic rock intrusives. It occurred to the writer, therefore, that the geology of Cuba might well be examined from a geological engineering point of view, taking advantage of the comprehensive studies that had already been made on stratigraphic and sedimentary relationship. It was found that very little work had been done on the relationship between the hard rocks, basic and acid, altered and unaltered, the sedimentary rocks affected, and the paleo structural geology of the areas subjected to magmatic intrusions. Some work had been published, as such studies had a bearing on the concentration of minerals in potential ore bodies, but none in relationship to oil accumulations.

Geologic History Examined

The scope of this article does not permit a detailed exposition of the concepts, and bases for these concepts, brought to Cuba by the writer in 1948, but suffice it to say that these involved a study of the paleo geologic history of the entire Caribbean area; a region lying between two so-called stable continental masses; a dynamic area of tectonic turbulence, whose boundaries have become more and more restricted and/or shifted through geologic time from the Pre-Jurraisic to the present.

It was only natural, therefore, to approach the study of Cuba as a unit part of a system, playing its part in the result of balancing the many forces applied to the system as a whole. The tectonic history of the island was, therefore, the one that was chosen as the springboard to field research. Not only were the hard rocks chosen for study because of their association with oil, but because it was felt that the history of movements might be most indelibly stamped in these.

Detailed field work in the four areas permitted an understanding of the nature of formations, their inter-relationship; physical, chemical, and age sequence, and established directions for further investigations on the trail of sedimentary basins and probable structures within them. The trail led to areas of the island where hitherto unsuspected sedimentary basins, important as potential producers of oil, were lurking. Recent drilling has proved in part that original conclusions supported by field evidence were sound.

Cuban geology presents a challenge to the exploration geologist. He must be an engineer versed in the theory of structures, strength, and competence of varying materials in plain and structural form; a geophysicist familiar with the constitution of the earth and its crust; a mineralogist and petrologist who knows cause from effect; a paleontologist fully aware of environmental effect as modifications of geologic time; an individual, above all, able to reduce images resulting from the correlation of data to graphic form, to admit that time itself is exponential, and to visualize form and substance accordingly.

Formations Present

If Cuban geology presents a challenge to the geologist and demands the most from his preparation, training, and experience, the solution of prob-

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Double Shut-In Pressure Readings Provide More Information — In Less Time — Than Other Methods

"WHAT IS THE main advantage of double shut-in pressure readings?" That's a question often asked by those who have not yet tried this newest method of drill stem testing.

Actually there are *four* main advantages of the double shut-in pressure method:

1. Maximum formation pressure build-up in shortest time.
2. Comparison of reservoir build-up pressures before and after test.
3. Two separate chances to obtain reservoir pressure.
4. The measuring of the true equilibrium pressure prior to producing the formation provides a virgin pressure measurement and more accurate data.

Perfected by Johnston Testers, this new technique requires only a simple rearrangement of the test tool assembly. By placing a disc valve above the main or hydraulic valve, a specified volume of air is trapped between these two valves. This volume of air is called the "air chamber."

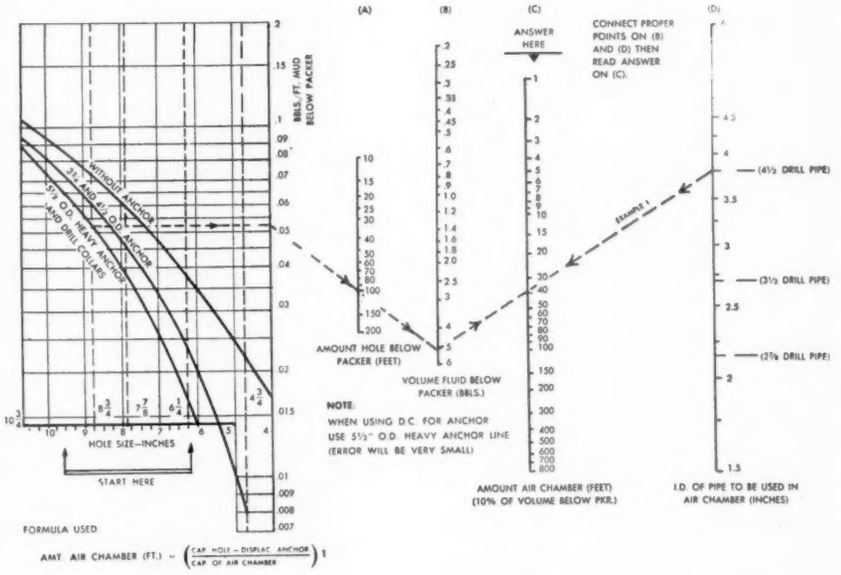
As the purpose of the air chamber is to relieve the mud pressure trapped below the packer, the secret of success of double shut-in testing is accurate use of this air chamber. Best results have been obtained when volume of the air chamber is about 10% of the volume of mud below the packer.

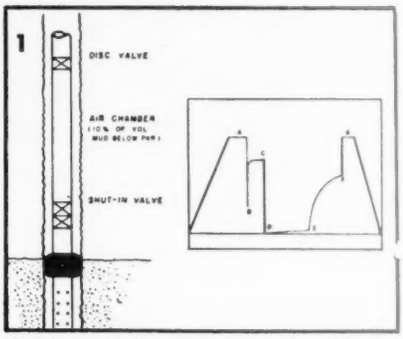
In the past, it has been common to calculate the air chamber to the nearest 30-foot pipe length. This lack of accuracy has often caused a failure to record the *maximum* initial shut-in pressure.

To overcome this problem, and to do away with complicated mathematics, Johnston has developed an "air chamber alignment chart." By simply drawing straight lines between known figures, the amount of air chamber needed can be calculated quickly and accurately.

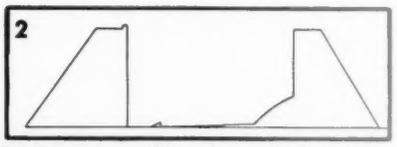
The chart below shows how simple it actually is to use this method.

Complete information on double shut-in testing is available from Johnston Testers, Houston, Texas. Write today for complete descriptive folder.

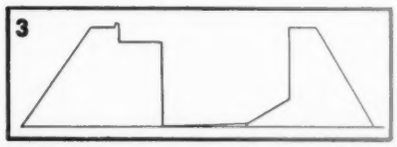

(A)
(B)
(C)
(D)
BBLS./FT. MUD BELOW PACKER
WITHOUT ANCHOR
3½" AND 4½" O.D. ANCHOR
5½" O.D. HEAVY ANCHOR
AND DRILL COLLARS
HOLE SIZE—INCHES
START HERE
ANSWER HERE
CONNECT PROPER POINTS ON (B) AND (D) THEN READ ANSWER ON (C).
AMOUNT HOLE BELOW PACKER (FEET)
VOLUME FLUID BELOW PACKER (BBLS.)
NOTE:
WHEN USING D.C. FOR ANCHOR USE 5½" O.D. HEAVY ANCHOR LINE (ERROR WILL BE VERY SMALL)
Example 1
(4½ DRILL PIPE)
(3½ DRILL PIPE)
(2⅞ DRILL PIPE)
AMOUNT AIR CHAMBER (FEET) (10% OF VOLUME BELOW PKR.)
I.D. OF PIPE TO BE USED IN AIR CHAMBER (INCHES)
FORMULA USED
AMT. AIR CHAMBER (FT.) = (CAP. HOLE − DISPLAC. ANCHOR / CAP. OF AIR CHAMBER) 1



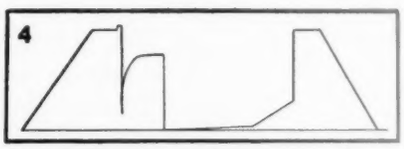
Testing tool assembly for double shut-in pressure readings which permits a limited fluid withdrawal. By placing the disc valve above the main or hydraulic valve so that a specified volume of air is trapped between these two valves.



Well not capable of producing fluid fast enough to fill up air chamber and cause pressure build-up.



Mud did not expand enough to get pressure draw-down below the formation pressure.



Mud expanded and pressure draw-down was below the formation pressure. Well was able to flow enough fluid to fill up air chamber and build-up shut-in pressure.

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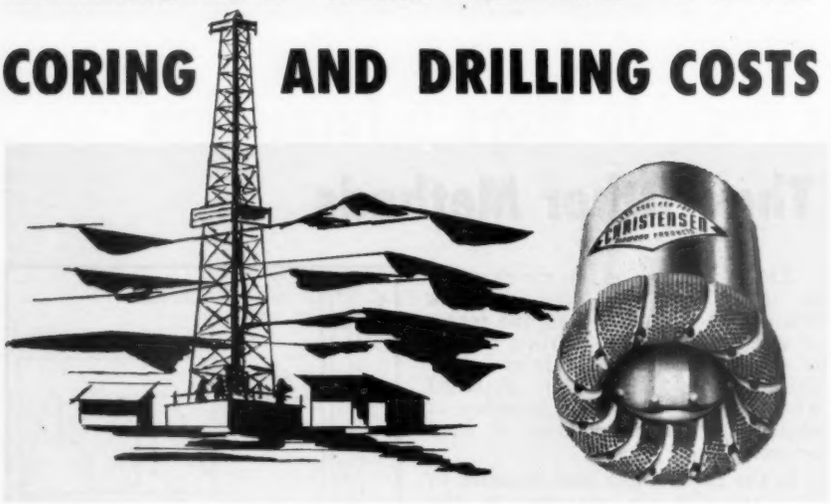

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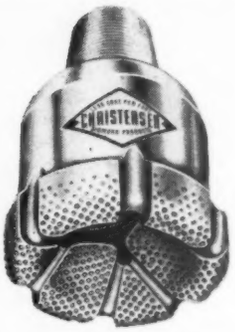

FORMATION BIT SIZE	TOTAL FOOTAGE	PENETRATION RATE	TOTAL COST	BIT COST PER FOOT	BIT LOAD POUNDS	RPM	FL. VOL.
BETHANY FIELD, PANOLA COUNTY, TEXAS							
Pettete and Travis Peak 6⅛"x3½" Core Bit	1000 ft.	4 ft./hr.	$1600.00	**$1.60**	6,000-12,000	60	200 gpm
WILDCAT FIELD, LINCOLN COUNTY, LOUISIANA							
Travis Peak 8⅝"x5¼" Core Bit	725 ft.	3 ft./hr.	$2145.30	**$2.96**	8,000-16,000	50-60	275 gpm
QUALEY DOME FIELD, ALBANY COUNTY, WYOMING							
Red Beds 6-3/16" Drilling Bit	638 ft.	2 to 3 ft./hr.	$ 846.05	**$1.33**	5,000-12,000	70	230 gpm
WERTZ FIELD, CARBON COUNTY, WYOMING							
Tensleep	408 ft.	1½ ft./hr.	$2187.11	**$5.34**	12,000	60	250 gpm

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lems confronting the petroleum engineer, even so, will be no less challenging in the drilling of all kinds of formations and completion of wells when oil is discovered.

It is safe to assert that examples of almost every kind of formation now being drilled somewhere in the world will be encountered in Cuba during the exploratory drilling period. It is almost certain that the following types will be encountered:

Sandstones: Quartz and lime.

Conglomerates: Basic and acid rocks, sedimentary clastics limes, dolomites, shales, and tuffs.

Fractured Igneous: Serpentines, volcanics.

Limestone: Reef or cavernous.

The Author

Florent H. Bailly is head of Petroleum Engineering Associates and Oil Properties Consultants, Inc., and Litholog, Inc. A native of Venezuela, Bailly attended school at the California Institute of Technology, where he received a degree in engineering. He returned to Venezuela and was employed by the Pantepec Oil Company as a field engineer. Bailly was promoted progressively up the ladder until he was elected president in 1949. He resigned from that office in 1950. He is also active in oil exploration in the western United States and Cuba.

Structures likewise diversified in nature such as anticlines, domes, faults, or sedimentary traps, among which reefs may be counted, all may be expected.

Human Challenge

The petroleum engineer must do his best to solve problems that arise and must draw upon the experience and training of the oil industry. The challenge to the geologist and petroleum engineer by Cuban geology has been accepted, and there is no doubt oil in substantial commercial quantities will be found. The search will be prolonged, and ample and satisfying rewards delayed unless professional men directing the search acknowledge the complexity of the problem, accept the challenge, and bring to bear in its solution the vast store of knowledge and engineering experience already available.

Cuba is a pleasant, friendly place, and there will be a temptation to daudle, relax, and vacation. This temptation, which is strong, must be resisted or else Cuba's oil may be left underground much longer than it need be. *

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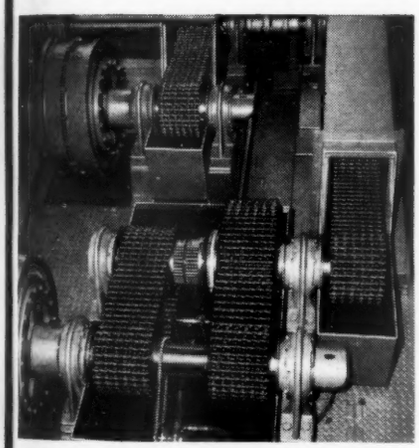

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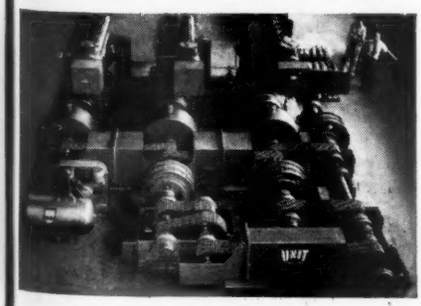

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Unique Application . . . .

Plunger Lift Removes Water From Gas Wells

Flow is Doubled in Two California Wells

GAS flow of two California wells has been increased by a novel use of plunger lift equipment to pump out underground water. Installations were for Superior Oil Company, in Cymric Field and for Artnell Oil and Gas Company, near Coalinga. In both cases, gas volume was reported doubled when water level was reduced.

The plunger lift method normally is used for pumping oil from wells. For pumping water from a gas well, the same subsurface equipment is used, and tubing is broached, as in oil wells, to be sure plunger will travel freely. Surface control system may be considerably different, however.

If a large percentage of gas is to be taken from casing, and if there is considerable sand, it may be necessary to place motor valve on the casing discharge line. Closing the motor valve intermittently, either by pressure or time control, causes well to build up, forcing plunger to the surface with its load of water. As soon as the plunger strikes trigger cam, motor valve opens again and the casing pressure starts to drop. This, in turn, reduces volume of gas coming through tubing, so that plunger may again drop to the bottom of the tubing for another load.

For wells producing 500 mcf per day or less, a simpler arrangement, using a pressure reducer made up to 100 feet of 3/16 in. tubing, is suitable, as shown in Fig. 1. Pressure is reduced about 200 lb per sq in. by frictional loss, eliminating some of the freezing troubles experienced with reducing regulators. Pressure reducer also keeps fluid from accumulating and clogging the small reducing regulator. If sand conditions are severe, micro-choke and motor valve are moved downstream from scrubbers or high pressure separator. Sand is dropped out before reaching motor valve, thus preventing abrasion of valve seat.

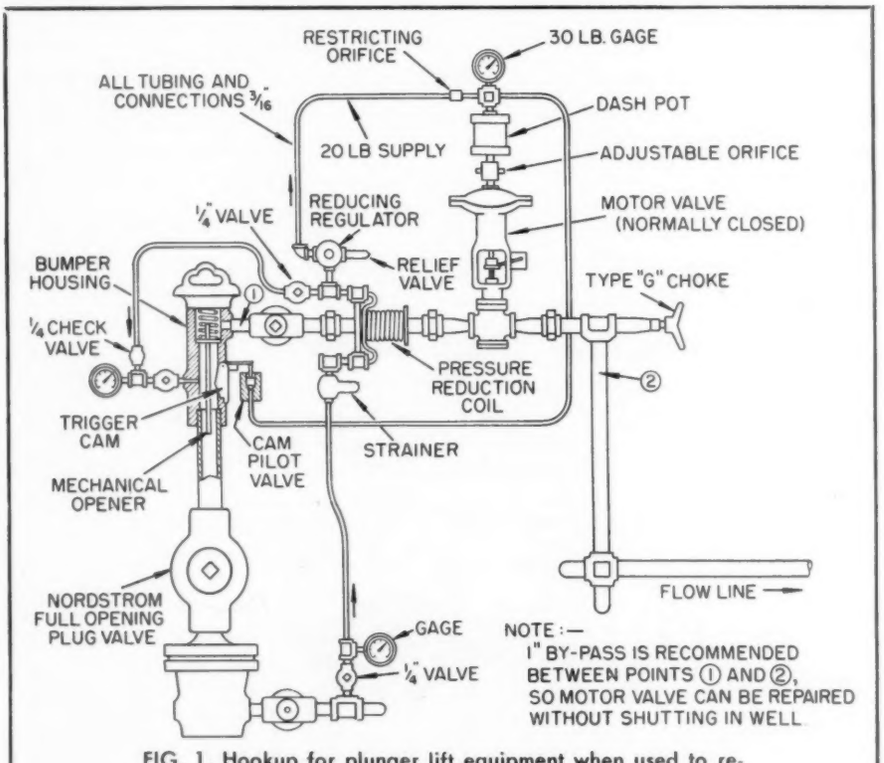


FIG. 1. Hookup for plunger lift equipment when used to remove water from the bottom of a gas well to increase its productivity.

How It Works

When plunger reaches bumper housing, the plunger valve is opened by the mechanical opener, and trigger is depressed. This action bleeds off dash pot through cam pilot valve, allowing valve to close rapidly and plunger to fall.

As the plunger disengages trigger, the cam pilot valve closes, thus applying pilot pressure to dash pot. Adjustable orifice can be set up so that the motor valve opens slowly, giving the plunger time to reach the bottom of tubing.

On reaching the bottom, plunger valve is closed and plunger, propelled by gas, returns to the surface with its fluid load. After fluid is discharged, plunger enters bumper housing, completing cycle. * * *

A New Subsurface Exploration Tool . . .

Lithologic Well History Logs

Complete Well Data, Presented Graphically, Descriptively and in Color Give the Full Story

Paul J. Lewis
Northwest Geological Service

THE most recently developed tool for the subsurface exploration geologist is the lithologic well history log. Its development is in response to the need for the subsurface geologist to assemble in a composite and concise form those various tools he uses.

To date, the log has been applied to the problem of regional correlation and subsurface facies studies. Fortunately, the log was initiated early in the development and exploration of the Williston Basin. As further logs are issued in conjunction with the continued activity in the Basin, the office or well-sitting geologist will have available concise data on wells from areas of particular interest or proposed exploratory tests. The research geologist, who often works at some distance from his subject area, finds the logs of exceptional value as his own files do not contain detailed data on such subjects as drillstem tests, completions, etc.

The lithologic well history log consists of nine component parts: (1) Graphic and/or colored lithologic column; (2) written lithologic description; (3) formation tops; (4) drillstem test intervals and recoveries; cored intervals; (5) completion data; (6) discussion; (7) complete drillstem test data; (8) detailed core description and (9) electric log and/or radioactive log.

The graphic lithologic column is the basic component with which all other parts are integrated. This column shows by graphic symbols the total series of rocks as penetrated by the drill. The lithology must be determined by an experienced and specialized geologist. It is at this point of the log preparation that the most accurate and comprehensive work must be done. The geologist must constantly be aware of not falling into routine and preconceived lithologic determination. Minor changes must be recognized and noted. In an area such as the Williston Basin, the well density is exceedingly low. Many future oil fields will be located in facies that have not as yet been encountered by the drill. The ability to recognize minute sedimentary changes is not gained overnight, nor has every geologist the ingrained aptitude to become an expert logger.

More Details Necessary

As the initial influx of geologists to the oil industry changed the "shell," "blue rock," etc. to more concise and accurate terms, so the specialized logger of today has gone beyond the average industrial level of logging technics to incorporate more exacting data in the log. This point can be shown by the present methods of handling limestones.

There has become a pressing necessity to gain more detailed knowledge of the carbonate rocks. It has been the common practice to describe color, crystallinity and texture. Such a broad terminology covers many individual carbonate horizons under one common set of terms. In the new logs, an attempt is made to base the carbonate description on those characteristics that reveal the environment of deposition. The author believes that a high percentage of carbonates were deposited or modified prior to consolidation by agitated water conditions. Therefore, the carbonate rock is scanned for those criteria that denote such agitation. The terms calcarenite, calcirudite, etc. are very appropriate and useful terms. (A calcarenite is a rock composed of grains of calcium carbonate which have been abraded by agitated water. The grain size ranges from 0.1 millimeter to 2.5 millimeters). When the texture of the rock obscures the true character, a thin section is made. After a sufficient number of thin sections are made and viewed by an experienced sample logger, most characteristics, as seen under the binocular microscope, can readily be described without resorting to a thin section of each change of character.

EXCLUSIVE

Graphic Column Amplified

The descriptive column amplifies the graphic column by giving a complete written description, all of which may or may not be represented graphically. The written description is set forth in a systematic order so that through constant repetition the various lithologic features are checked by the logging geologist. A sandstone is described in the following order: (1) Sedimentary type, (2) color, (3) minimum grain size, (4) maximum grain size, (5) average gain size, (6) external grain characteristics, (7) matrix, (8) minor or subsidiary characteristics in order of relative importance.

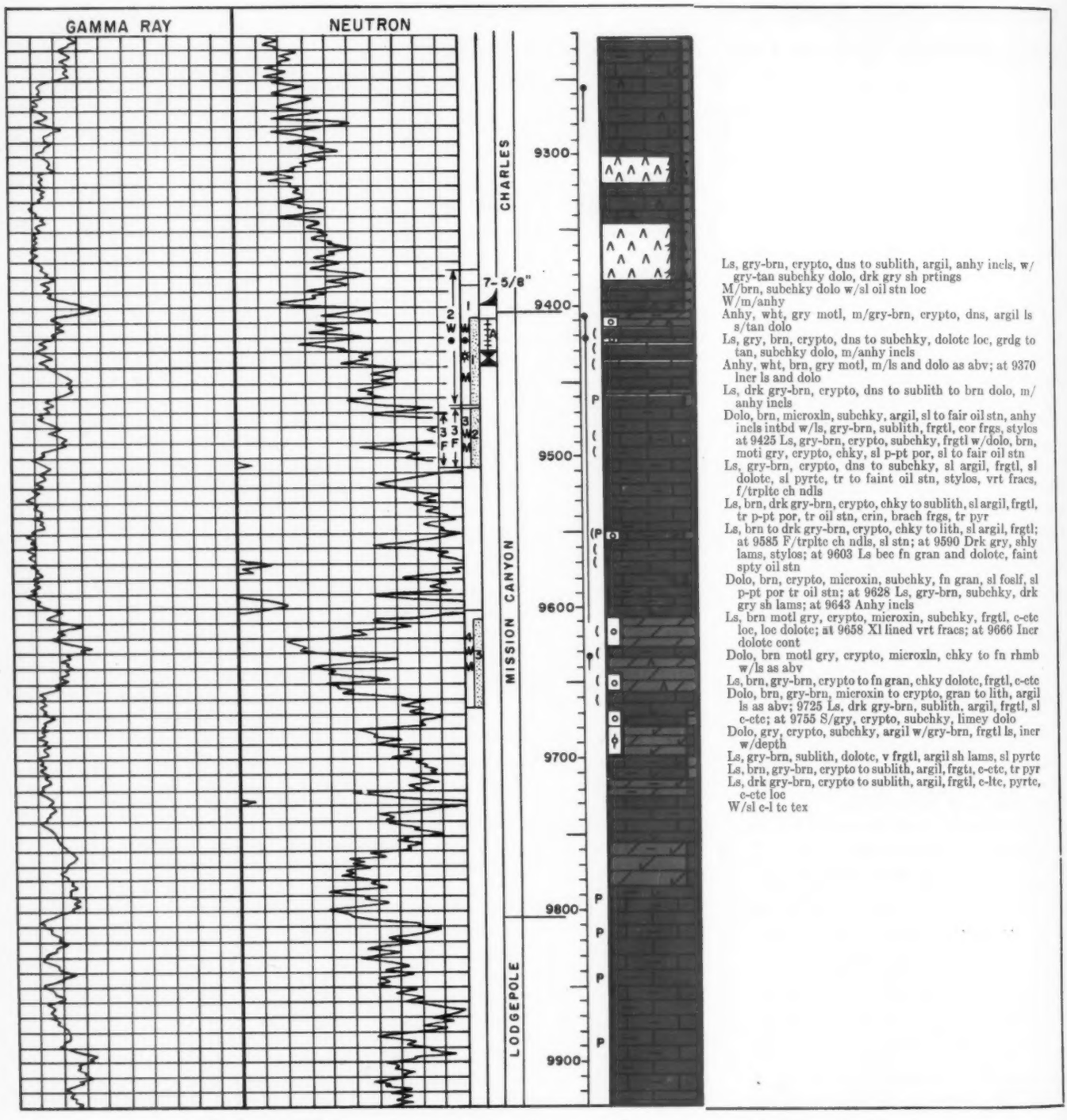
Formation tops, drillstem test in-

XUM

tervals and recoveries, core intervals and completion data are placed in vertical columns to the left of the lithologic column and depth figures. In the first column are placed the formation names which vary from area to area and from basin to basin. It is uncommon for all geologists of the oil industry in a given area to agree on what lithology constitutes the top of an individual formation. It is too often that "kicks" on the mechanical logs are given preference over actual lithology. Correlation pitfalls are numerous in such unexplored areas as the Williston Basin when the electric or radioactive log can be slipped up and down until a correlation materializes. The author recalls the advent of a geologist to the Williston Basin from a southern area where mechanical logs are considered the "bible." The geologist sat in bewilderment at his desk as the author entered his office.

"Look at this correlation! Perfect, kick for kick. Except that I have a Devonian section aligned with a Mississippian section. What do I do?"

Fortunately, at least in the Williston Basin, the pendulum is swinging back to the basic foundation of geology, the study of the rocks themselves. Each of the tools developed for the exploration geologist has its use as long as the geologist realizes the capabilities and limitations of each. The all inclusive


GAMMA RAY
NEUTRON
CHARLES
MISSION CANYON
LODGEPOLE
7- 5/8"
9300
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Ls, gry-brn, crypto, dns to sublith, argil, anhy incls, w/ gry-tan subchky dolo, drk gry sh prtings
M/brn, subchky dolo w/sl oil stn loc
W/m/anhy
Anhy, wht, gry motl, m/gry-brn, crypto, dns, argil ls s/tan dolo
Ls, gry, brn, crypto, dns to subchky, dolotc loc, grdg to tan, subchky dolo, m/anhy incls
Anhy, wht, brn, gry motl, m/ls and dolo as abv; at 9370 lncr ls and dolo
Ls, drk gry-brn, crypto, dns to sublith to brn dolo, m/ anhy incls
Dolo, brn, microxln, subchky, argil, sl to fair oil stn, anhy incls intbd w/ls, gry-brn, sublith, frgtl, cor frgs, stylos at 9425 Ls, gry-brn, crypto, subchky, frgtl w/dolo, brn, moti gry, crypto, chky, sl p-pt por, sl to fair oil stn
Ls, gry-brn, crypto, dns to subchky, sl argil, frgtl, sl dolotc, sl pyrtc, tr to faint oil stn, stylos, vrt fracs, f/trplte ch ndls
Ls, brn, drk gry-brn, crypto, chky to sublith, sl argil, frgtl, tr p-pt por, tr oil stn, crin, brach frgs, tr pyr
Ls, brn to drk gry-brn, crypto, chky to lith, sl argil, frgtl; at 9585 F/trplte ch ndls, sl stn; at 9590 Drk gry, shly lams, stylos; at 9603 Ls bec fn gran and dolotc, faint spty oil stn
Dolo, brn, crypto, microxin, subchky, fn gran, sl foslf, sl p-pt por tr oil stn; at 9628 Ls, gry-brn, subchky, drk gry sh lams; at 9643 Anhy incls
Ls, brn motl gry, crypto, microxin, subchky, frgtl, c-etc loc, loc dolotc; at 9658 Xl lined vrt fracs; at 9666 Incr dolotc cont
Dolo, brn motl gry, crypto, microxln, chky to fn rhmb w/ls as abv
Ls, brn, gry-brn, crypto to fn gran, chky dolotc, frgtl, c-etc
Dolo, brn, gry-brn, microxin to crypto, gran to lith, argil ls as abv; 9725 Ls, drk gry-brn, sublith, argil, frgtl, sl c-etc; at 9755 S/gry, crypto, subchky, limey dolo
Dolo, gry, crypto, subchky, argil w/gry-brn, frgtl ls, incr w/depth
Ls, gry-brn, sublith, dolotc, v frgtl, argil sh lams, sl pyrtc
Ls, brn, gry-brn, crypto to sublith, argil, frgtl, c-etc, tr pyr
Ls, drk gry-brn, crypto to sublith, argil, frgtl, c-ltc, pyrtc, c-etc loc
W/sl c-l tc tex

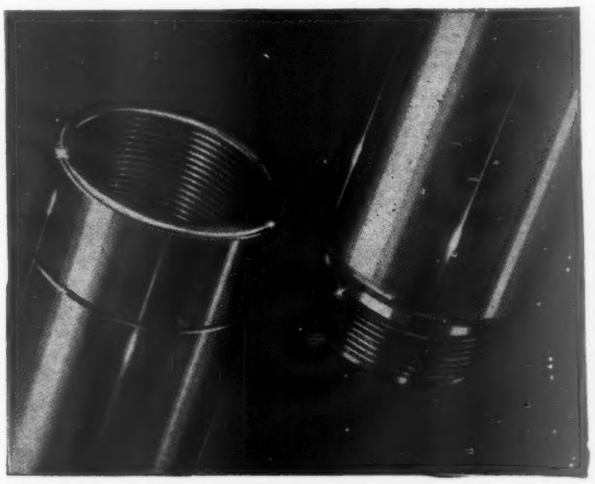
FIG. 1. Typical lithologic well history which contains nine component parts. Due to printing difficulties, only two colors are indicated, and these are not the standard colors normally employed.

This is trouble...

This unretouched photo shows a plunger section taken from a pump operating in a Mid-Continent oil field. The extreme pitting indicates what corrosive and abrasive action can do to a pump part when it is not metallurgically suited to the well condition. A wrong specification of parts for the specific well condition might be the cause of failure.

This is trouble-free...

Here's why ... Axelson has available, not one, but *many* different plungers, each designed for a *specific* well condition. Axelson is the only pump manufacturer operating *its own foundry,* thus establishing complete quality control for alloy castings. Super rigid physical and chemical specifications guarantee quality of carbon alloy and stainless steel tubing. These are some of many reasons why Axelson plungers have: (a) the proper strength to absorb shock loading and so minimize fatigue; (b) high resistance to corrosion; (c) maximum hardening to resist abrasion.



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and final log has not been made by the logging geologist nor by mechanical methods.

Completion Data

The next column to the left contains the completion data of producing wells tested through pipe. Again the data is condensed into graphic and symbolic form. A full compilation of the completion data is given at the end of the well history log. Zones of plug backs, perforations, acidization, squeezing, etc. can be noted at a glance. Many man hours can be saved on this feature alone, permitting the office geologist to concentrate on more important aspects.

Intervals of drillstem tests and cores are graphically presented in the last vertical column to the left. Recovery of drillstem tests are abbreviated by letter and graphic symbols as the complete result is too voluminous for such a space. Details of the drillstem test are given in full at the end of the log. The cored interval is also shown graphically. Description of the core usually must be condensed and generalized in the graphic and written lithologic columns, as the space limitations of the 100 ft to the inch scale are too restrictive to give full details. This problem is amply handled at the bottom of the log with a complete description.

Written Comments

The logging geologist mentally compares the section under examination with his knowledge of the area and the same section in surrounding tests. An alert logger cannot help but come up with fundamental concepts of the geology of the area. In order not to lose these observations, a discussion of the pertinent points as observed is written by the logging geologist. This discussion is considered one of the most valuable portions of the log. It satisfies, as far as is humanly possible, the problem of an exploration geologist who must use logs analyzed by others, since time will not permit his personal examination of samples from all wells in his area.

Drillstem Tests

Below the discussion, a complete and detailed report of drillstem test results and core examination is inserted. Here, the drillstem test data will give more details of component recoveries, pressures, salinities, etc., than can be shown graphically as noted above. All detailed data placed on the log is obtained from the operator if possible. The conclusive evaluation of the capabilities of a zone by means of a drillstem test is open to much debate. Numerous cases of poor results on drill stem tests from zones that are finally completed as prolific producers leaves much to be desired in evaluation by this method.

Lithologic Analysis

Following the compilation of drillstem test results, a complete and descriptive lithologic analysis of the cores is given. This includes the cored interval, recovery and foot by foot lithologic description. This section of the log can become quite voluminous. In fact, the length of some core descriptions have exceeded the actual length of the graphic log. Considerable expense has been incurred by the operator to obtain cores. These data should be preserved in the best possible manner.

Well Log Included

To the far left of the lithologic log is placed the electric and/or radioactivity log. The various tools of the industry should be employed by the exploration geologist but not to the exclusion of other data. The mechanical log selected, whether electric or radioactivity, is dictated by what logs the operator ran on the hole. If both types are available, the log that best appears to interpret the lithology is selected by the logging geologist. In many cases in the Williston Basin, the upper shale and sand section is best portrayed by the electric log. In the carbonate section, the radioactivity log is most usable. Thus, in most cases, the electric log is used down to the carbonates below which the radioactivity log is inserted. Only one resistivity curve is traced on the log. It is not the intention to supply a full electric log from which a reservoir engineer can compute his data. Other services distribute such logs.

Such a logging service as herein described by necessity must be built on obtaining and preservation of ditch and core samples from all wells in the

FIG. 2. Portions of the discussion, drillstem test and core data included in the lithologic well history log.

DISCUSSION

The Charles section, particularly through the salt series, was difficult to analyze due to poor samples. The limestone of the Charles are basinal deposits with some irregular porosity due to probable secondary dolomitization. The zone 9195 to 9225, in samples, had good staining with fair permeability from irregular dolomite streaks. This zone appears capable of production. Production tests:

Ran tubing to 9431 and set packer at 8928. Acidized w/5000 gallons. Opened well to pits through ¾" choke. First hr. flowed 33.3 bbls of fluid, 26% BS, 36.4% water, 0.8% mud, TP 300, GV 727,000. Second hr., 25.43 bbls of fluid, 4% BS, 2% water, 0% mud, TP 400, GV 396,000. Third hr., 22.68 bbls of fluid, 1.2% BS, 1.6% water, TP 300, GV 512,000. Flowed 324 bbls oil and 165.55 bbls water in 21 hrs. on 2¼" choke, TP 200, GOR 790–1, gravity 40.1. Flowed 392 bbls oil and 167 bbls water in 24 hrs. on 2¼" choke, GOR 501–1. Killed well.

DRILLSTEM — TESTS

D.S.T. #1:	9386—9466;	Weak blow 40 min., fair blow 30 min., packer failed, rec. 4100′ fluid as follows: 2000′ heavily oil and gas cut water cushion, 710′ sl oil and gas cut water and 1390′ sl gas cut rotary mud, HP 5350#, IFP 1050#, FFP 1450#, No BHP
D.S.T. #3:	9468—9508;	Test failed
D.S.T. #3: Run #2	9471—9508;	Test failed
D.S.T. #3: Run #3	9469—9508;	Open 4 hrs., Sl 15 min., air immediately, v weak blow for 4 hrs., reversed out 2000′ muddy water cushion, 2000′ drilling mud w/no show of gas or oil and 500′ gry, sl salty water, IHP 5200#, FHP 5175#, IFP 1100#, FFP 2100#, BHP 3775#
D.S.T. #4:	9601—9666;	Open 2 hrs., Sl 15 min., air immediately, storng blow, water cushion to surface in 45 min., flowed water cushion for 55 min.,flowed rat hole mud for 10 min., flowed fresh water for 10 min. at rate of 17 bbls per hr., reversed out, IHP 5400#, FHP 5450#, IFP 2850#, FFP 4425#, BHP 4550#

CORE DESCRIPTIONS

Core #1:	9408—9466	Rec. 58′
	9448—56½:	Ls, brn, crypto, chky, m/crin frgs, f/p-pt vugs, gd brn oil stn
	9456½—58½:	Dolo, brn, sl motl w/gry, crypto, chky, f/crin frgs, sl p-pt vug por, fair brn oil stn
	9458½—59:	Dolo, tan sl motl w/gry, crypto, chky, sl argil, f/crin frgs, sl oil stn
	9459—66:	Ls, gry-brn, crypto, dns to subchky, sl argil, f/crin frgs, doloct, sl pyrte w/bare tr of oil stn
Core #2:	9466—9508	Rec. 36′
	9466—71:	Ls, drk brn, sublith, sl argil, m/crin frgs, f/stylos, tr oil stn
	9471—76:	Ls, gry-brn, crypto, dns, sl argil, w/lt gry trplte ch ndls containing fn fos debris, f/large cor frgs, faint oil stn in ls
	9476—82:	Ls, drk gry-brn, crypto, dns to subchky, m/crin frgs, sl oil stn vrt fracs
	9481—86:	Ls, med gry-brn, crypto, subchky, w/m/crin frgs, faint oil stn
	9486—91:	Ls, drk gry-brn, sublith, argil, w/m/fn fos frgs, f/trplte ch ndls
	9491—96:	Ls, gry-brn, crypto, chky, w/m/crin and branch frgs, sl oil stn
	9496—9503:	Ls, gry-brn, crypto, subchky to dns, m/brach and crin frgs, faint oil stn, stylos
	9503—08:	No smpls
Core #3:	9608—9666	Rec. 58′
	9608—28:	Dolo, brn, crypto to microxln, fnly gran, crin and brach frgs; at 9618 Sl p-pt vug por
	9628—33:	Ls, gry-brn, crypto, subchky, m/drk gry sh laminae, m/crin frgs, sl dolote
	9633—38:	Dolo, brn, crypto to microxln, chky, tr oil stn
	9638—43:	Dolo, brn, subchky w/ireg strks of fnly gran, sl vuggy anhy incls and vns
	9643—58:	Dolo, brn, crypto, subchky, fn fos frgs, f/anhy incls, w/sl p-pt vug por; at 9653 Dolo grds to fnly gran w/incr p-pt vugs
	9658—63:	Ls, brn motl w/gry, crypto, subchky, m/fos frgs, crins, brachs and cors, f/p-pt vugs, calc, xls lined vrt fracs
	9663—66:	Ls, brn sl motl w/gry, cryto to microxln, subchky to microgran, dolote, frgtl, w/f/p-pt vugs, sl c-l tc

area of operation. For each company to maintain a complete sample library and processing facilities would create an unnecessary cost to all companies. A privately operated organization is the most efficient method to accumulate and disseminate this material. The material must be available to any and all interested parties. The collection of samples is a cooperative endeavor in the industry, the operation of which is entrusted to an organization independent of any operator.

Records Should Be Kept

In some areas the independent operators have taken the attitude that samples are of little value and therefore do not bother to collect or preserve them. In general, the larger operators and companies make a noteworthy effort to preserve this basic material. Many times the wildcatter will scoff at geological methods but he seeks farm-outs or attempts to follow the plays of those operators with geological staffs. Indirectly, he is using geological data as fully as any large company. The wildcatter or small operator has a valued and proper place in the industry. Thus, as an active member of the oil industry, he should do his part in the preservation of this important information. As the industry prospers, so will he.

Color Used

The application of a system of colors for the various sedimentary rocks adds considerably to the usability of the lithologic well history log. This feature is illustrated in Fig. 1. Often, it is of considerable advantage to the exploration geologist to place a series of logs on a correlation board or wall so as to obtain an understanding of the changing sub-surface conditions over a large area. When viewed from a distance, the various lithologic units in color are readily separable to the eye. Such is not the case with the black and white symbols.

There have evolved many color systems among the various oil companies and geologists. Attempts for standardization of an industry-wide color pattern have met with failure. The colors employed on the lithologic log are those most commonly used by the greatest number of operators. The response has been favorable, with some operators modifying their systems in order to conform. Those companies with a large number of previous lithologic logs based on a system of considerable difference find it advantageous to purchase black and white logs and to have their staff color these to their own color pattern. * * *

From Canada

Socony-Vacuum Oil Co. of Canada Ltd. has become Mobil Oil of Canada Ltd. Telephone numbers and office addresses remain unchanged. The Barron building has now been re-named the Mobil Oil Building.

Trafford & Associates Limited has been taken over by Colorado Oil & Gas Corporation.

Ponder Oils Limited has been acquired by Amurex Oil Development Company.

Rio-Prado Consolidated Oils Limited and Palmer Oil Development Company Ltd. may now be found under the new name Rio Palmer Oils Limited.

Canadian Petrofina Limited has purchased control of Western Leaseholds Ltd.

Mill City Petroleums Limited has amalgamated with Mercury Oils Limited.

Vermillion Consolidated Oils Limited has been taken over by Blue Crown Petroleums Limited.

Antone Petroleums Limited has been acquired by American Leduc Petroleums Ltd.

Plymouth Oil Company with offices in Calgary, is a newcomer to Canada.

Orecan Oils, with head office in Portland, Oregon, is now operating in Saskatchewan.

El Paso Natural Gas Company is a newcomer to Canada.

Houston Oil Field Equipment Company, based in Calgary, is now established in Canada.

Thomas W. Leach of Bismarck, North Dakota, is an independent operator newly active in Saskatchewan.

Great Northern Oil Purchasing Company, with head offices in Dover, Delaware, has joined the industry in Canada.

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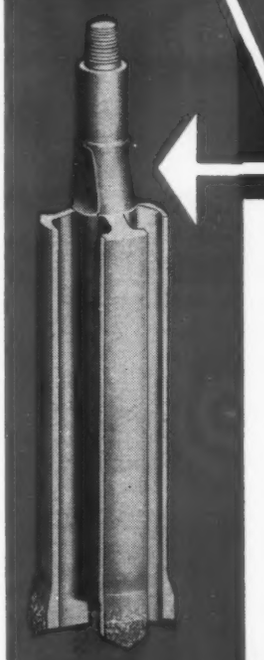

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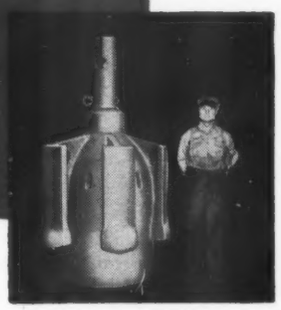

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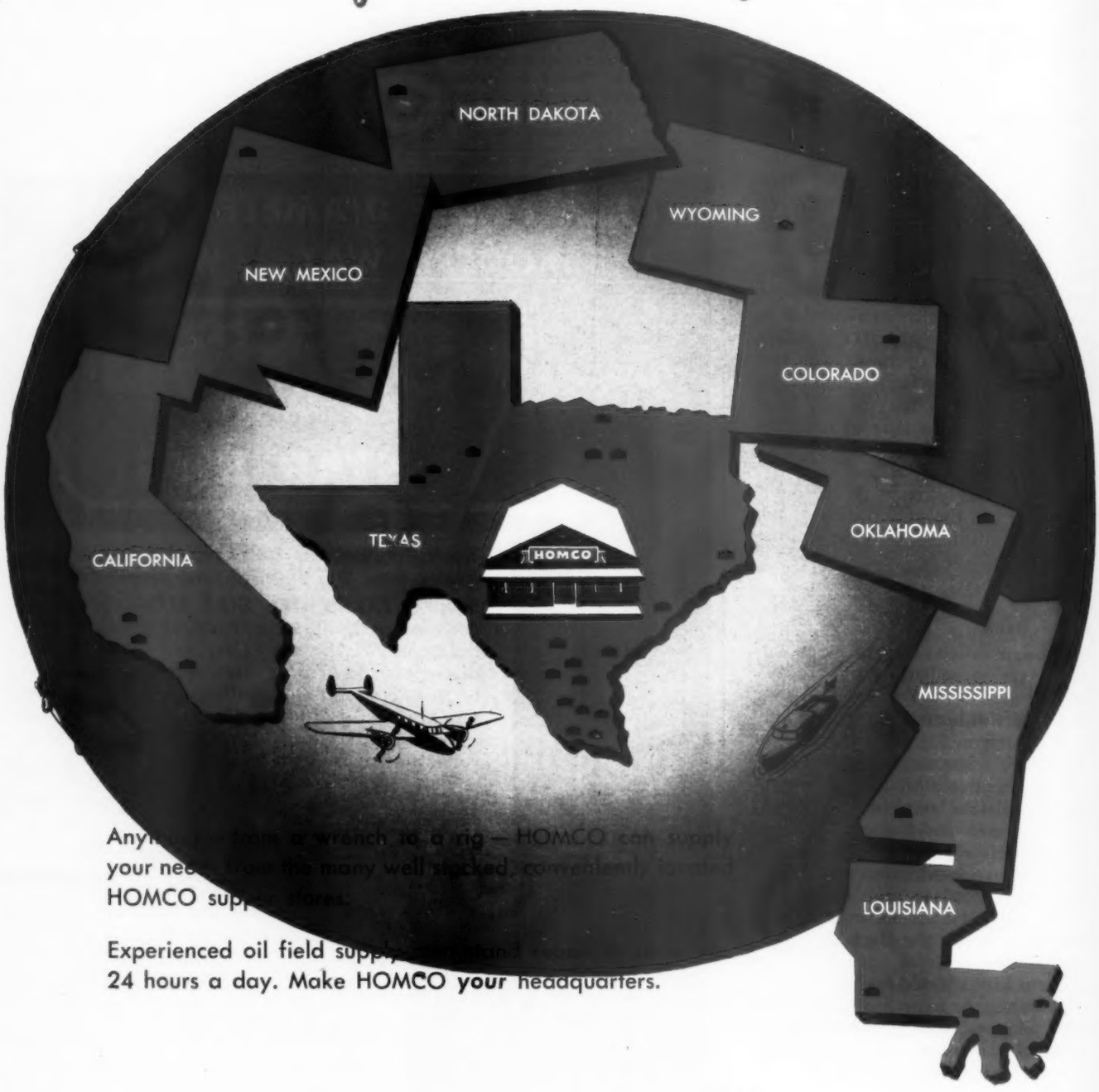

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New Fracturing Fluid

Additives in Lease Crude Provide Most Desirable Characteristics for Specific Well Conditions

Marion A. Whitfield, Roscoe C. Clark, Jr.

A NEW fracturing fluid in which two of the most important physical properties are varied to fit individual well and reservoir conditions is made by mixing additives in lease crude oil. These additives provide control of fluid characteristics of the fracturing material in somewhat the same manner as the characteristics of drilling fluids are controlled. In the case of this new fracturing fluid, those two important physical properties that now can be controlled are viscosity and fluid loss. Experience to date has indicated that these two factors contribute more than any other property of the fracturing fluid to the success of a job.

At first, it was not clear what would be the advantages of varying viscosity, and fluid loss arbitrarily was maintained consistently as low as was economically practicable. Now, however, operators are requiring fracturing fluids of varying viscosities according to individual reservoir conditions. In some areas, it is a general preference to maintain as low a viscosity as possible consistent with low fluid loss. In other areas, viscosities as high as 2000 centipoises have given results inferior to those obtained using viscosities higher than 3000 centipoises. Generally, determination of viscosity required has been dictated by the amount of sand that was found in the hole following treatment. In some cases, particularly in the case of treating shot holes, it has been necessary to provide relatively high viscosity in order to eliminate sand settling.

Value of Viscosity. At the time that hydraulic fracturing was first introduced, it was felt that fracturing fluids must possess a high viscosity in order to prevent "leak-off" to the porous formations at a sufficiently fast rate so that the pressure could not be built up high enough in the well bore to break down the formation. After the formation was broken down, it was still felt that viscosity was necessary in order to: (1) Prevent the sand from falling through the fluid in the well bore and refusing to enter the fractures (2) again prevent the fracturing fluid from leaking off to the porous matrix on either side of the fracture so the fluid could be retained in the fracture to extend in some distance away from the well bore.

EXCLUSIVE

Recently, it has been established that leak-off of fracturing fluid into porous rock can be controlled better by a positive shut-off of the fluid-flow into the rock, rather than by slowing down the loss of the fluids into the rock by using a high viscosity. Many wells have been successfully fractured using fracturing fluids having very low viscosities (in the neighborhood of 1 centipoise under bottom-hole conditions). These jobs have been conducted using very high injection rates and also by using low injection rates and imparting to the fracturing fluid the property of fluid loss. These successful jobs have shown that sand fall-out through the fracturing fluid while still in the well bore is not a serious problem whether or not a high viscosity fracturing fluid is used.

Recent developments in hydraulic fracturing have shown that the contributions of viscosity in fracturing fluids have been misinterpreted. Viscosity, however, does play a very important role in building effective fracturing solutions. The application of high injection rate and/or of low fluid loss

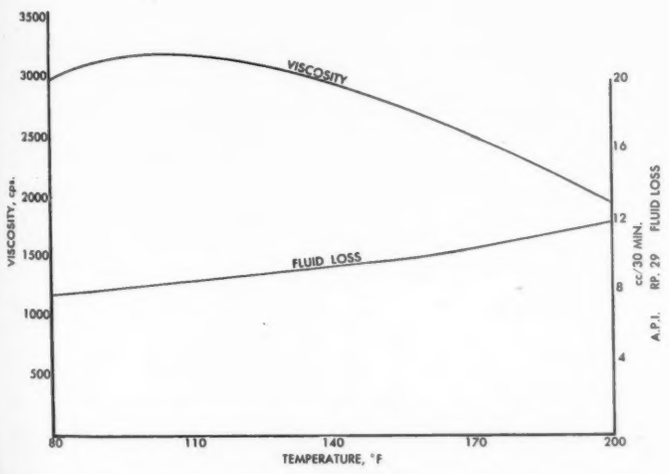

FIG. 1. Effect of temperature on viscosity and fluid loss of the new fracturing fluid.

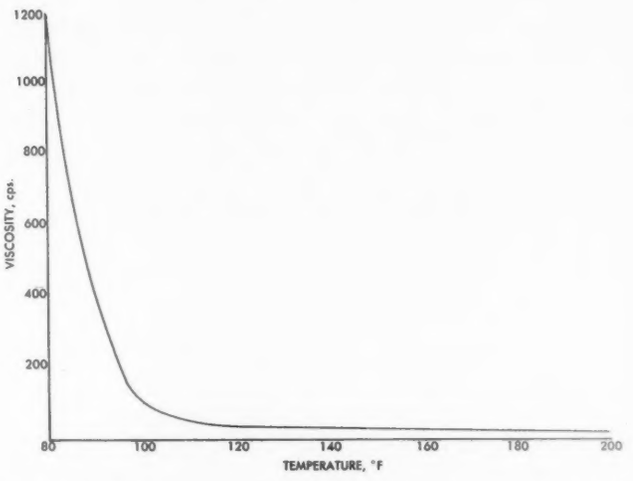

FIG. 2. Effect of temperature on the viscosity of an average fuel oil.

fracturing treatments has eliminated one need for viscosity and created another need for this property. This is particularly true when using low-fluid-loss fracturing solutions.

As a horizontal fracture is extended farther and farther away from the well bore, movement of the fracturing fluid becomes slower and slower until some point is reached at which the velocity of the fluid is too slow to transport sand farther into the fracture away from the well bore. This point is obviously reached much quicker in low viscosity fluids than in high viscosity fluids. There is no published data showing the rate of movement required for fracturing fluids of various viscosities to transport sand. The rate of fracturing fluid movement decreases as the square of the distance it is away from the well bore. It is, therefore, visualized that the distance away from the well bore at which a low viscosity fracturing fluid will no longer transport sand is fairly limited.

If maximum value is to be received from the treatment, it appears that even without data it would be desirable to have a high viscosity fracturing fluid in order to insure transportation of sand as far back from the well bore as possible. Data are forthcoming on this subject and will be of considerable help in planning viscosities desired for future fracturing treatments.

Although most low-viscosity, low-fluid-loss fracturing treatments have been successful, in some cases as much as 200 ft of sand has had to be cleaned out of the well bore following treatment. This fall-out apparently has not been sufficiently serious to affect results of the job, although it does increase the cost of the treatment by necessitating subsequent clean-out operations. There also has been some sand clean-out necessary following fracturing treatments using viscous fracturing materials. This has been the exception, however, rather than the rule. Use of a viscous fracturing material in most cases will prevent the necessity of cleaning sand out of the well following treatment.

TABLE 1. Average results from new frac fluid treatments in the Permian Basin.

Formation	Section	Amount		Injection rate	Production		30 days or longer
		Fluid	Sand		Before	After	
Grayburg	3857–4241	20,000	20,000	12	6	109	100
San Andres							
Grayburg	4728–37	3,000	3,000	3.4	no test	154	146
San Andres	4424–4750	10,000	20,000	5	3.5	20	15
Clearfork	5345–5986	10,000	12,000	2.8	7	150	100
Clearfork	5410–6000	10,000	12,000	5.44	19	—	93
Gardner	3948–62	3,500	7,500	5	15	250	235 (sanded up during treatment)
Gardner	3914–28	3,000	7,200	8	25	150	135
San Andres	5179–5246	10,000	10,000	6.4	3	42	38
Dolomite	2927–3172	6,500	9,000	7.7	5	20	17
Sims	7040–46	4,000	8,000	5	no test	—	218 (dual completion)
							187
Deese	4534–42	2,000	4,000	6.8	10	25	30
Cleveland	3454–80	6,000	6,000	5	good gas	123	123
Springer	5553–95	15,000	15,000	2.5	6	30	28
Eason	3957–88	5,000	10,000	5.7	no test	120	119
Delaware	4950–56	6,000	12,000	5.3	18	60	55
Cross Cut	1519–27	2,000	3,000	2.7	swabbed dry	8	8
Clearfork	5500–5890	10,000	20,000	8	22	—	114
Yates	3025–3584	10,000	10,000	6.6	200 MCF	4000 MCF	4000 MCF
Fry	3609–14	1,500	800	3	15	—	20
Red Fork	3280–97	6,300	7,500	6.8	no test	312	Exceeding allowable

Still another advantage of viscosity control is that it has been possible to build a lower fluid loss into viscous fracturing solutions than it has been into non-viscous fracturing solutions. The viscosity additive alone will provide a fluid loss ranging from 20 to 100 cc in 30 min at bottom-hole conditions. The addition of a small amount of fluid loss additive, therefore, makes it relatively easy to reduce the fluid loss to less than 10 cc.

Viscosity is a desirable property of a fracturing fluid during treatment. Immediately following the operation and during the period when the fracturing fluid is being recovered, viscosity becomes an undesirable property. During the recovery of the fracturing fluid from the formation, a high viscosity will tend to move the sand deposit in the fracture back into the well bore, thus decreasing effectiveness of the treatment and causing additional expense during clean-up operations.

The most desirable type of fracturing fluid, therefore, is one in which a high viscosity can be maintained during the fracturing operations, after which the fracturing fluid reduces to a viscosity comparable to native crudes. Viscosity of a crude oil generally will have little tendency to carry sand with its upon its return to the well bore. This is one of the distinct advantages of prepared fracturing fluids over residual fuel oils. In the case of the residual fuel oils, the same viscosity that carries the sand into the formation is tending to retrieve the sand from the formation. It is because of this factor that large amounts of flush oil are needed to prevent sand return on fracturing jobs using fuel oil. (In this connection, it appears likely that a small amount of a viscous flush should be equivalent to a large amount of a non-viscous flush. Where 200 bbl of a 35-deg API gravity crude oil have been used successfully for flush, somewhere between 10 and 20 of a viscous flush might prove equally effective.) Of course, in the case of using residual fuel oils, part of the value of the crude oil flush is in attempting to dilute and thus to decrease the viscosity of the fuel oil. This dilution, of course, is not needed when using a fracturing fluid that will break down to a low viscosity due to an internal breaker and where dilution of additional crude oil is not required.

In summation, then, it can be said

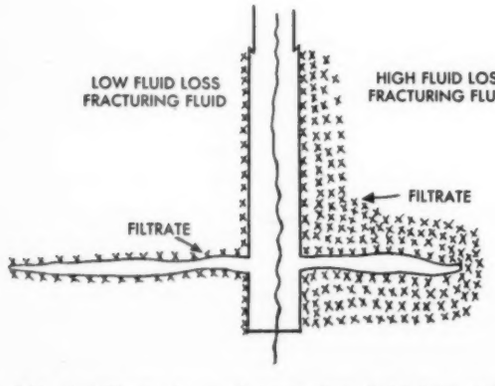

FIG. 3. Filtrate loss of fracturing fluid into the formation with low fluid-loss materials and with high fluid-loss materials.

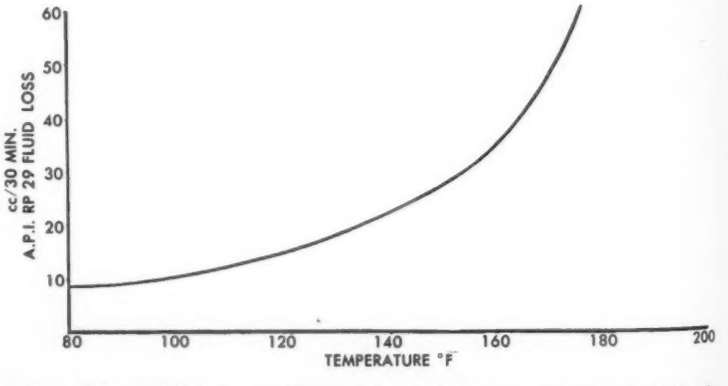

FIG. 4. Effect of temperature on fluid loss of an average fuel oil.

that the property of high viscosity in a fracturing fluid is desirable to prevent sand from settling to the bottom of the hole during the treatment and to insure the placement of sand as far away from the well bore as possible during the treatment. Viscosity is a particularly advantageous property when it can be controlled to the point where it exists at a high value during the placement of the sand and exists at a low value during the recovery of the fluid.

Effect of Fluid Loss. The principal limiting factor in creating hydraulic fractures is the distance to which the fracture can be extended away from the well bore. Until recently, this distance has been limited by the characteristics of the fracturing fluids available. During a fracturing operation, a considerable amount of fracturing fluid is lost to the porous matrix surrounding the well bore and on either side of the fracture. The area of formation exposed increases as the square of the radius of the fracture. It can be shown that for even a small fracture radius, a very large area of formation becomes exposed. Even though a fracturing fluid may be quite viscous, the "leak-off" to such a large area of formation becomes of considerable magnitude.

Because of this factor, it has been recognized recently that in addition to the property of viscosity it is desirable to include a property known as "fluid loss." This property is a familiar property in drilling muds and indicates the ability of the drilling mud to build up a filter-cake against the face of the formation and to resist further penetration into the formation (Fig. 3).

Many of the residual fuel oils that are in popular use today for hydraulic fracturing operations have low fluid loss properties at temperatures less than 100 F. Fig. 4 illustrates typical fluid loss properties of a residual fuel oil under various temperatures. The fluid loss of these fuel oils ordinarily remains at a low value as the temperature is increased and then suddenly a small increase in temperature results in a considerable increase in the fluid loss. This is probably due to the fact that the residual fuel oil contains paraffin or asphaltines in suspension. At a certain temperature, these paraffins or asphaltines dissolve in the oil, thus increasing the filtration rate or increasing the fluid loss property of the oil.

A very few residual fuel oils sometimes exhibit low fluid loss properties to temperatures as high as 140 to 160 F, although this type of resistance to fluid loss varies from batch to batch of oil. In addition, it is difficult to correlate the fluid loss properties of a residual fuel oil with the resistance of the oil to penetration into porous matrix. Thus, unlike drilling muds, the resistance of a fuel oil to passage through the filter paper in the API RP 29 Test does not necessarily indicate a corresponding ability to resist penetration into porous rock.

FIG 5. Fracturing treatment with residual fuel oil. Note the amount of equipment required for this type job.

FIG. 6. Less equipment is needed to treat wells with the new fracturing fluid as demonstrated below.

Because of the limitations of the fracturing fluids available, a number of laboratories have concentrated for the last few years upon developing fracturing fluids having very low fluid

TABLE 2. Comparative results of fuel oil vs new frac fluid in the Permian Basin.

	Formation	Section	Amount		Injection rate	Production		
			Fluid	Sand	bbl/min.	Before	After	30 days or longer
New frac fluid	San Andres Grayburg	approx. 4000–4200	10,000	15,000	10	2	—	42
Fuel oil	Off-set well	approx. same	20,000	40,000	high rate	4	—	28
New frac fluid	Grayburg San Andres	3900–4250	10,000	15,000	20	P8	—	F701 choke
Fuel oil	Off-set well	approx. same	20,000	40,000	high rate	P17	—	F419 choke
Fuel oil	Off-set well	approx. same	20,000	30,000	high rate	P12	—	F625 choke
Fuel oil	Off-set well	approx. same	20,000	30,000	high rate	P10	—	F289 choke
New frac fluid	San Andres Grayburg	3770–4180	15,000	30,000	8.8	P3	P76	P70
Fuel oil	Off-set well	approx. same	*	*	high rate	P3	P68	P43
New frac fluid	Clearfork	5410–6000	10,000	12,000	5.4	19	—	93
Fuel oil	Off-set well	approx. same	*	*	33	19	—	98
New frac fluid	Springer Sand	*	6,000	12,000	2	8	—	52
Fuel oil	Off-set well	approx. same	*	*	high rate	20	—	52

* Information not available.

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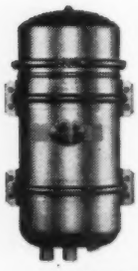

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loss properties. The fracturing fluid desired was one that would quickly build up a filter-cake against a porous formation. This filter-cake would limit to a high degree the passage of fluids through it into porous rock.

Such a fluid has been developed using an additive introduced recently by the Continental Oil Company. Laboratory studies and field results indicate that this material quickly builds up an impermeable filter-cake against the face of a porous rock with the loss of a very small amount of fluid. It has been found that these wall-building properties can be correlated between the API PR 29 Fluid Loss Test and the actual penetration into porous rock. Fluid loss has been held to less than 10 cc in 30 min on most treatments made with this new fracturing fluid. Calculations indicate, and field results have substantiated, that when using a 10 cc fluid loss fracturing fluid, a greater portion of the fracturing fluid remains in the fractures extending them to greater depths. As the fluid loss approaches values larger than 10 cc, the reverse becomes true in that major portion of the fracturing fluid becomes lost to the porous matrix and less material is left to extend the fracture.

It can be shown that with fluid loss properties such as those described above, extension of fractures becomes insensitive to injection rate, regardless of how fast the fracturing fluid is displaced into the fracture. The "spurt-loss" will be the same, and this loss will represent the major portion of the fracturing fluid loss to the porous matrix. Thus, an injection rate of 5 bbl per minute into a fracture should produce essentially comparable results to an injection rate of 40 using the same volume of fracturing fluid. The only limitation on injection rate using a low-fluid-loss fracturing material is that the injection rate must be high enough to keep the fracture pumped sufficiently wide open to allow the passage of sand into the fracture.

Many wells in the Permian Basin are completed in such thick producing sections that during a single-stage fracture treatment, many fractures are opened and injection into these fractures must be maintained. If an injection has been established into say 5 fractures at one time, and the injection rate is too low to keep one of the 5 fractures sufficiently wide open to accept sand, then a screen-out of the whole treatment is likely to occur.

Low-fluid-loss fracturing fluids can be saved the cost of high injection rate treatments. The amount of this saving will be based on the length of the producing section to be fractured. Injection rates of 5 should normally be adequate for producing formations having

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a thickness of 40 ft or less. As the thickness increases beyond 300 to 400 ft of formation, the injection rate should be increased to 15 to 25. These injection rates should eliminate a majority "screen-outs."

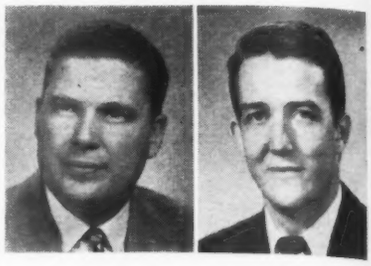
Less Equipment Needed. Since so little of the fracturing fluid is lost to the porous rock, less fracturing fluid can be used than normally has been possible with residual fuel oils while still obtaining as good or better results. This means that less pumping equipment, less mixing equipment, and less oil storage equipment can be used to conduct a fracturing treatment without decreasing the effectiveness of the treatment. This is illustrated in Fig. 5 and 6. Fig. 5 is a picture of a typical residual fuel oil high injection rate treatment. Fig. 6 is a picture of a typical treatment using the newly developed fracturing fluid. The effect of the new viscosity and fluid loss properties can, be better appreciated in terms of equipment required to do each job.

Compatibility. Compatibility in this fracturing fluid is not a problem, since oil obtained from the reservoir to be fractured can be used to make up the fracturing fluid. At the completion of the treatment, this fracturing fluid then breaks down into the original crude oil and can be sold as pipe line oil.

Results To Date. Several hundred wells have been treated with this new fracturing fluid. It would be incorrect to state that excellent results have been obtained in every case. There have been occasions when unsatisfactory results have been obtained and a few cases where high injection rate residual fuel oil treatments would have been better or did later produce better results. Ninety-five per cent of the treatments conducted to date, however, have produced production increases. In nearly every case, these results were obtained at considerably less cost than otherwise would have been possible. Table 1 is a tabulation of the results of 20 treatments. Included in the tabulation are the treating conditions. Of greatest note in this tabulation is that while results have been as good as, or better than, those obtained in the high injection rate treatments, the injection rates and total volume of fluid, and thus cost of treatment, have been considerably less.

In several cases, it has been possible to design experimental treatments using a new fracturing fluid in off-setting wells in which high injection rate residual fuel oil treatments have been conducted. Results of these tests are presented in Table 2. It can be seen from this tabulation that comparable to, or

The Authors



R. C. Clark M. A. Whitfield

Roscoe Clark is director of research for The Western Company at Midland. He holds an MS in petroleum engineering from the University of Tulsa. Upon leaving the service, he was employed by Dowell, Inc., as a service engineer. His experience in research and development was obtained in the research departments of Stanolind Oil and Gas Company as senior research engineer and at Continental Oil Company as supervisor of the engineering section.

Marion A. Whitfield has been actively engaged in research and development of new fracturing fluids and was recently promoted to director of the chemical engineering department of The Western Company with headquarters at Midland, Texas. He attended West Texas College and was graduated from the University of Texas with a master's degree in chemistry. He taught chemistry and physics in high school for two years prior to joining Western in 1953.

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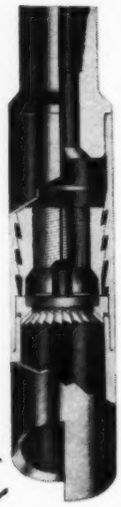

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better, results were obtained at a cost approximating half that required for residual fuel oil treatment.

Acknowledgment

The authors wish to express their appreciation to the personnel of the many producing companies. Their advice and help in the original field testing made this new fluid possible. Appreciation is also expressed to the operations and sales divisions of The Western Company for their advice and help in the development of this new fluid, and to the management of The Western Company for permission to publish this paper.

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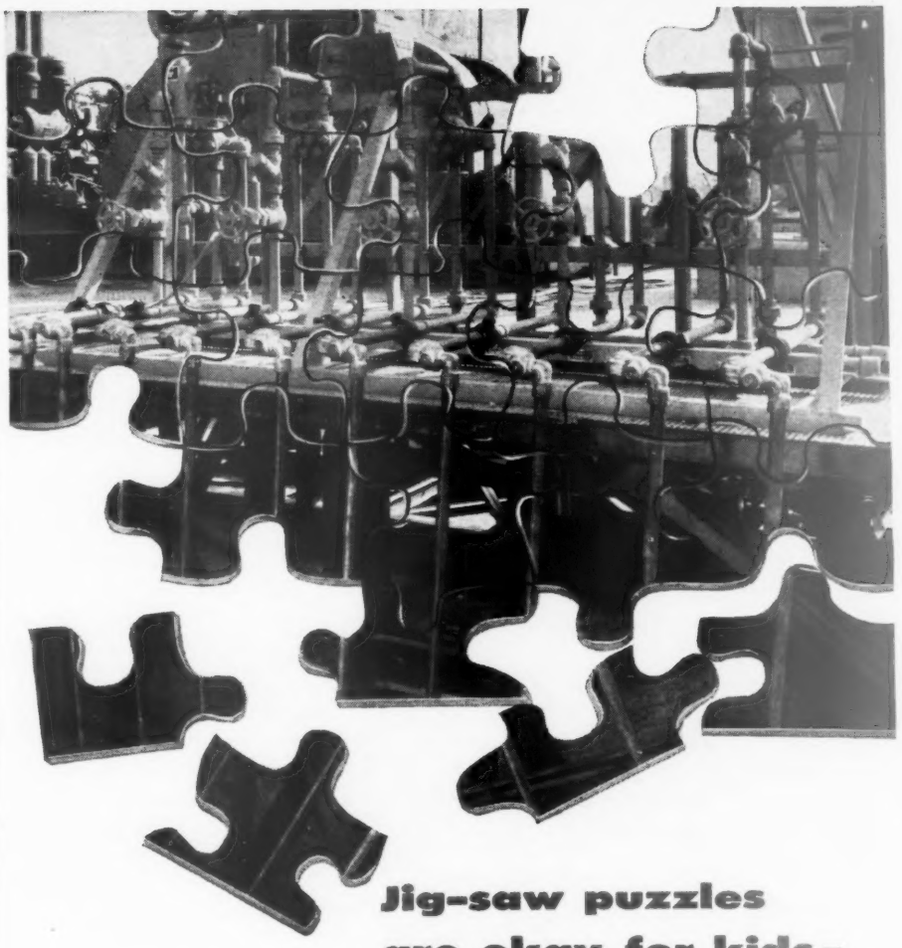

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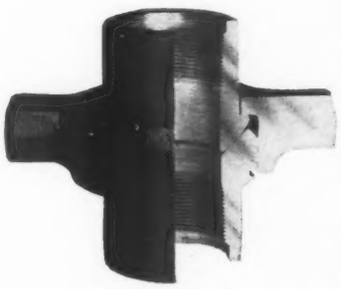

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It offers rapid surface reconnaissance evaluation at low cost

Norman C. Smith
Kenneth M. Renfro

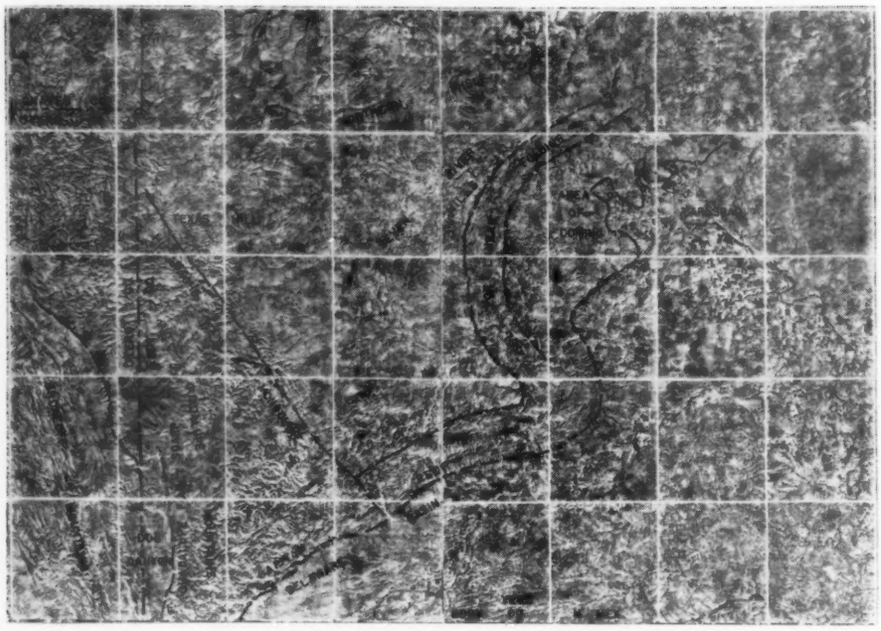

FIG. 1. Mosaic of the Guadalupe Reef in southwestern Eddy County, New Mexico, illustrating the benefit of small scale, continuous coverage for mapping regional geology.

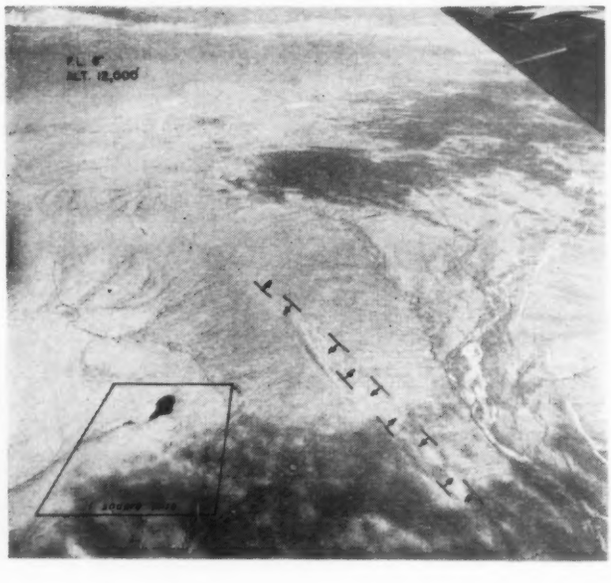

FIG. 2. Left wing oblique trimetrogon photo of tightly folded syncline in Cretaceous terrain of northern Alaska showing perspective and large area of coverage offered by this type photo.

AERIAL photography is one of the newer and more vesatile exploration instruments to become available to the petroleum industry. As with most technical methods, it has been impossible for all except the specialists to keep informed on the many improvements in air photography and its interpretation during the last decade.

Photogeology has undergone a period of rapid growth related to general advances in exploratory techniques stimulated by greatly increased needs for petroleum during and since World War II. Photogelogy passed through an adolescent phase during which it was enthusiastically hailed as an independent device that could reduce the industry's exploration problems to simplicity itself. The early over-optimistic period was succeeded by a more rational stage of youthful development characterized by the gradual recognition of a fundamental relationship to geology and a natural interdependence upon geological and geophysical evaluation.

During the past few years, photogeology has reached the age of maturity that entitles it to a regular berth on the oil-finding team. This is due to the combined efforts of oil company staff geologists, several specialized exploration organizations, and a number of independents. As with the individual, photogeology's maturity is evidenced not by its years, but by a growing ability for self-analysis that recognizes its limitations as well as its capabilities.

At this significant stage in the development of a unique exploration tool that has revitalized the study of surface geology, it is appropriate to summarize its range of application and speculate upon its future in the integrated exploration program.

The function of management is to select methods most suited to the problems at hand so that discoveries may be

EXCLUSIVE

made as early as possible with minimum costs. The development of geological interpretation of air photos has brought an effective tool within the reach of even the smallest exploration budget. Offering rapid reconnaissance evaluation at low cost, it is a logical basis for an integrated exploration program for large and small companies alike.

Many major companies now employ geologists who are trained in the use of air photos. Other majors and some smaller companies with budgets that cannot support a fulltime specialist avail themselves of the services of consulting firms and individuals. It is fair to say that to some extent photogeology has served as a sort of equalizer in tending to give the large and small operator an even start in the search for oil. As with any exploration technique, the extent of discovery success is dependent upon the degree of agressiveness and intelligence with which the available data are used.

Accurate Data

From the early days of direct exploration for evidence of oil and gas in seepages, the industry has come to depend exclusively upon indirect methods that deal with favorable environments for the generation and accumulation of hydrocarbons. Most accepted indirect exploration methods are subject to inborn variations in operational technique, which tend to produce a correspondingly wide variation in unprocessed data before interpretation. Photogeology, in this respect, has a certain initial advantage. The air photo is a literal reproduction of the earth's surface with true size and space relationships. It provides the ultimate in accurate raw data, subject only to the limitations imposed by the geologist's ability to interpret the information.

Many Improvements

The air photo has been improved in quality by advances in film sensitivity, the use of specially adapted filters for variable atmospheric conditions, and improvement in the resolution of lenses. Continued improvements in materials and equipment will meet the industry's needs as they become evident through more extensive use.

Two Types

The most common type of photography available today is vertical coverage at an approximate scale of three inches to the mile. The most effective application of vertical prints is in the study of three-dimensional models provided by the use of the stereoscope and overlapping prints. Vertical photography can be most accurately controlled in scale. Certain advantages of

FIG. 3. Strongly faulted, asymmetrical anticline in the Paradox Valley, East Central Utah. Prominent Rocky Mountain structures are easily recognized and mapped on mosaics and stereoscopic contact pairs.

FIG. 4. Mosaic of a portion of the Louisiana Gulf Coast area showing surface reflections of four prominent piercement-type salt domes. They are, from upper left to lower right: (A) Jefferson Island, (B) Avery Island, (C) Weeks Island, and (D) Cote Blanche.

FIG. 5. Vertical photograph of Avery Island, South Louisiana, showing greater detail with larger scale. Compare this view with same area shown in Fig. 4.

FIG. 6. Mosaic of a portion of Sabine Parish, Louisiana, near the Zwolle field, showing the occurrence of an inlier of the Catahoula formation, probably due to faulting.

FIG. 7. Mosaic of a portion of Wood County, East Texas, showing remarkable drainage adjustment in narrowed floodplain of a trunk stream crossing a graben at the Merigale-Paul field, and right-angle convergence of tributary drainage controlled by bounding faults. The graben marked has been confirmed; there are two other possible grabens indicated.

continuity, regional features, perspective, time and cost are obtained, however, through the use of less common oblique photography. Oblique photographs are taken with the camera lenses pointed at a predetermined angle from the vertical. The lower, usable portion of the oblique photo under common specifications, covers approximately six miles on either side of the line of flight. This greatly reduces the time and number of photos required for total photographic coverage.

The desirable attributes of perspective and controlled scale are to a great degree combined in the mosaic. The mosaic is constructed by assembling individual vertical photographs to form one single picture. The adaptation of scale and type of photography to be used is dictated by terrain conditions and the amount of detail to be mapped.

Widest Use

The area of most intensive application of photogeological exploration has been in mountainous regions of bold outcrop. This is true especially in the Rocky Mountains, where fostered by the industry's need of low-cost exploration for what at first appeared to be limited reserves and nurtured on respect earned by discovery experience, photogeology received its great impetus. In high-relief terrain, where visual mapping of beds with vertical stereo coverage is relatively unhampered, geologists achieve a degree of speed and accuracy with photo interpretation that outmodes unaided field mapping. Field work can be restricted to key areas where aerial mapping criteria are checked and structural trends are verified. The resulting economy in the expenditure of time and manpower has been worth an inestimable amount to the operating companies. Few successful operators now explore the mountainous areas and outlying basins without using photo analysis in both reconnaissance and detailed phases of exploration.

Covered Areas

A lesser known and generally unappreciated application of photo interpretation is its widespread usability throughout the Mid-Continent and coastal regions of low dip, where outcrops are generally obscured by a variable thickness of soil or dense vegetation cover. Although aerial mapping can usually be accomplished in varying degrees of detail, outcrop belts are frequently too broad and individual beds too indistinct to permit direct structural interpretation. Recognition of structural influence on such surfaces is more closely allied to topographic interpretation of land-forms and related drainage anomalies.

In most portions of the interior and coastal plains, unaided visual analysis of mosaics is usually preferred to stereoscopic examination. Instead of an exaggeration of the surface, it is desirable to obtain perspective from mosaics that permit the trained eye to recognize continuity in fragments of geological information scattered through a complex mass of ground detail. The restored picture of the structural framework and aerial distribution of lithologic units usually is based on careful observation and simple geological reasoning that is often impressive to the untrained observer.

Foreign Exploration

The early and more obvious use of photo analysis was for reconnaissance in regions of sparse geological control.

The Authors

N. C. Smith K. M. Renfro

Norman C. Smith is a consulting photogeologist in Dallas. He received his BA degree from Washington and Lee University and obtained graduate credits from Harvard and Oklahoma Universities. He combined early geological field experience in Venezuela with Creole Petroleum Corporation and later with Humble Oil & Refining Company on the Gulf Coast with military photo intelligence training while with the Navy in the Pacific Theater during World War II to attack his first photogeological interpretation assignment for the U. S. Navy. This covered the U. S. Naval Petroleum Reserve in Alaska. During six years as an independent, he has completed photo mapping projects over more than 125,000 square miles, including portions of all domestic petroleum provinces as well as Canada, Guatemala, and Cuba.

Kenneth M. Renfro, a photogeologist for The Atlantic Refining Company in Dallas, Texas, currently is in Delft, The Netherlands, where he wil study at the International Training Centre for Aerial Survey for one year under a Fullbright Scholarship. He first noted the application of aerial photographs in mineral exploration while director of a provincial bureau of mining and industry in Korea with the U. S. Military Government in 1945. Later, he studied at the University of Oklahoma where he received his BS and MS in geology. He spent two years as associate geologist with the Arkansas Division of Geology and two years as subsurface geologist with Sinclair Oil and Gas Company. He joined Atlantic in 1953 as photogeologist.

Although domestic frontier areas for initial exploration are by no means exhausted, a significant application of increasing interest is in foreign exploration. Under the normal sequence of development required by most governments, early exploration is essential to avoid the blind acquisition of large blocks of costly evaluation. Many areas of current interest are located in the least accessible desert and tropical regions of the world. Exploration activity involving the movement of field crews and equipment is often hampered by muskeg, shifting sands, or dense vegetation. None of these obstacles is insurmountable to photo interpretation and, under certain conditions, they are an aid. The operator who with rapid photo analysis develops a comprehensive concept of the regional geology of new provinces and isolates specific areas for detailed exploration is much better equipped to apply intelligently for concessions.

With Other Methods

Some of the most rewarding results have been obtained in areas where subsurface and geophysical data were available. A photogeological project initiated under these conditions might well begin with a careful analysis of the surface vicinity of all known structures in the area. This preliminary study develops a knowledge of specific mapping criteria that are applicable locally. The approach can be broadened by an intensive study of the regional relationships that would involve tracing the influence, either directly on visible beds or indirectly by soil, vegetation, and relief characteristics of the principal fault and fold axes. Coupling these photo studies with subsurface studies develops a knowledge of the tectonic history of the region and an appreciation of the type, size, and density of structures to be expected. Detailed photo studies may then be projected into areas of sparse control to form a basis for coordinated evaluation of both surface and subsurface prospects.

Old Photos Valuable

Literally millions of dollars have been spent by oil companies in the acquisition of air photos. Many of these photos have seen service only as rather costly road maps for geophysical crews. Probably the major portion of these purchases are today lying unused in company files, representing an appreciable capital investment and containing an inestimable wealth of data. Yet, these sources of information are bypassed because of a prevalent belief that a specialist is required to process them.

It is true that the photogeologist has

an advantage of experience. Regardless of a lack of specific experience in reading air photos, however, there can be no better equipped specialist than the geologist who has a thorough knowledge of his area. Given a reasonable ability to observe, the informed geologist has greater initial chance of recognizing the patterns of topography, soil, and drainage that reflect adjustment to familiar structural elements.

No New Science

Contrary to belief in some quarters, photogeology involves no new science. The photogeologist is primarily a geologist who has adapted his powers of observation to deciphering geological relationships from above. To the trained geologist accustomed to three-dimensional thinking, this is no radical adjustment. Through practice, he will become adept at adjusting mentally to changing scales and varied provinces.

It is not a lack of specialized skill that keeps oil companies from getting the most good from their photographs and keeps other companies from acquiring them. The fundamental lack is manpower, for the average company geologist does not have the time to undertake a photo interpretation project. The situation can be remedied by hiring a fulltime staff specialist or the part-time services of a consultant with the purpose of revising the exploration program to utilize photogeology in every practical phase.

Versatility

The basic versatility of air photos to allied problems in non-petroliferous mineral exploration, in routing of pipe lines, highway construction, city planning, forestry, and a wide variety of military applications, points the way to an even greater future. Indications are that most major companies will in a few years have organized central photo interpretation units for research and large-scale projects outside their current operating territory. In a similar period, many companies will disperse trained photogeologists to the operating divisions for concurrent evaluation. An accompanying development will be the acquisition of photo coverage of the entire operating territory in mosaic form in more than one scale, conforming to the scales of base maps used, to provide a basis for both regional and local evaluation.

The effect of bringing photogeology into the exploration program in a permanent and vital capacity will be to serve management as an unprecedented basis for integrating exploration efforts. With a history of wide application and proved achievement, photogeology shares with the petroleum industry a justifiable confidence in the future success of the continuing search for oil.

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For those readers who may be interested in exploring the general subject of photogeology further, a selected reading list is appended. References to sources of more technical information can be obtained from these general works.

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Acknowledgments

1. Aerial maps in Fig. 1, 4, 5, 6, and 7, courtesy Tobin Aerial Surveys, San Antonio, Texas.
2. Aerial photo in Fig. 2, courtesy U. S. Navy.
3. Aerial map in Fig. 3, courtesy Soil Conservation Service, U. S. Department of Agriculture.

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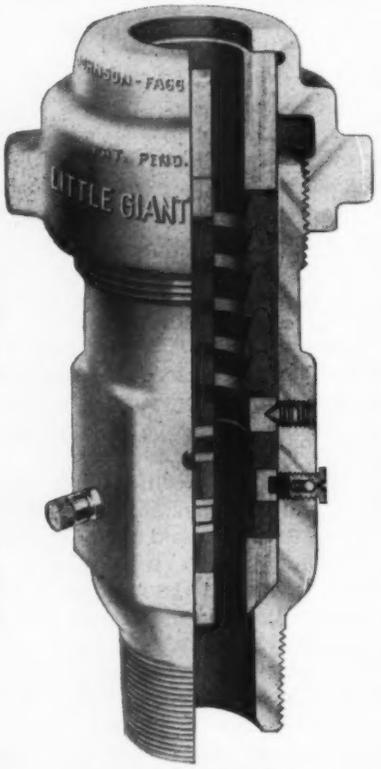

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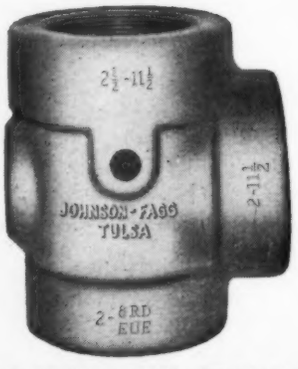

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GOLF PRIZE WINNERS at Los Angeles Whing Ding (back row): G. R. Winder, Chiksan Company; Jay Curtis, Gulf Publishing Company; Jack Augsberger, Triad Service; Bill Huskey, Hillman-Kelley; Karl Krieger, Richfield; (front row): Howard Hoon, Hydril Company; Truman Beeson, Specialty Sales Company; Howard Kaylor, Creole Petroleum; Paul Bowen, S. R. Bowen Company; Gene Madsen, H. C. Smith Oil Tool Company.

THE OASIS—*A gathering spot for Nomads*

HOUSTON CHAPTER, at its July meeting, had several guests. Seated are: Lucien Weltzer, French Equatorial Africa Oil Company, Paris, France; John Chestnut, consultant, Los Angeles; H. J. Veenick, NNGPM, Sorogg, New Guinea; standing, Jake Aston, Horton Equipment, Fort Worth; Frank Simms, Socony, Caracas, Venezuela; Bill Dudley, Gulf Publishing, Houston; Darrell Lawless, Horton Equipment, Houston; John Shirley, Ralph M. Parson Company, Ankara, Turkey; W. J. Green, Reed Roller Bit, Houma, Louisiana; A. H. Manson, Asiatic Petroleum, Houston; Harold Hall, Reed Roller Bit, Houston; J. L. Lloyd, Shell, Caracas, Venezuela; Wm. M. Laird, Hardy-Griffin, Houston; Pierre Lichtfouse, French Equatorial Africa Oil Company, Paris, and M. A. Roca, LaPaz, Bolivia.

GOLFERS—112 of them—turned out for New York Spring Golf Party in Springfield, New Jersey. Winners are: Left, R. T. Meek, Ladish Company, low gross Nomad; J. W. Chanda, A. O. Smith Corp.; W. Briggs, M. W. Kellogg Company; T. Donahue, Russell & Stoll; W. H. Busold, Bill Foster Associates. Below, J. B. Roberts, Chain Belt; J. George, Mid-Continent Supply; E. F. Gahan, E. F. Gahan, Inc.; R. A. Murphy, Rockwell, and C. H. Hesse, Val Wittich, Inc.

XUM

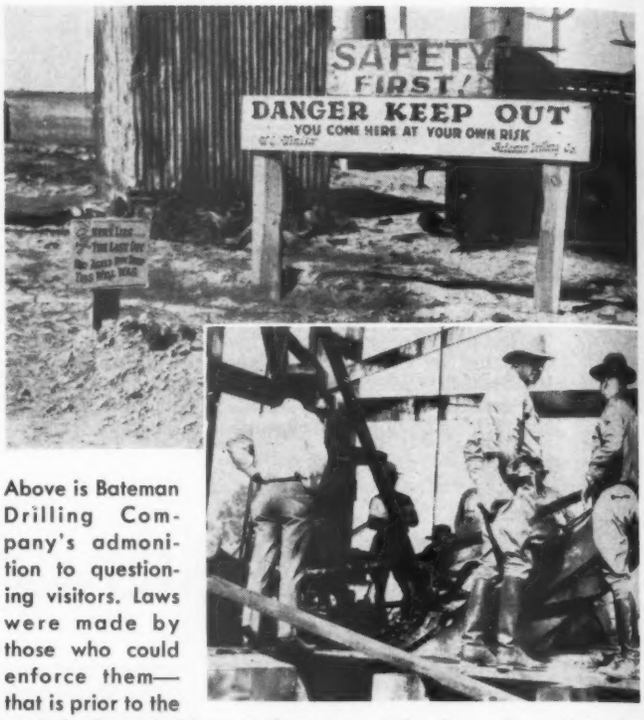
East Texas Field Marks Anniversary

Boom days are being recalled this month as the East Texas oil fraternity pays tribute to C. M. "Dad" Joiner and his discovery well, the No. 3 Daisy Bradford. The field opener, on the edge of the pool that was eventually to encompass a 42 by 9 mile area, was drilled on borrowed time and borrowed money. Joiner was paying his crew with leases and completed his well on a 60-day lease extension.

Field development was rapid. A second discovery, the E. W. Bateman-L. D. Crim No. 1, was completed three days after Christmas in 1930. Following the discovery of the two initial Rusk County wells, the Moncrief-Farrell et al No. 1 Lathrop, in Gregg County, tied the field together.

By the time the fourth well in the field was completed, oil was selling for 25 cents a barrel. By mid-1931 1000 wells were producing from the Woodbine sand at a depth of about 3600 ft. Extensions to the field came fast. In May, 1931 Mudge Oil Company found oil six miles north of Gladewater, and the Flanagan Production Company found an extension the same month, on the Whitehurst lease in Upshur County.

Production companies, pipe lines and refineries flocked into the area to alleviate a quickly flooded market. With them — or because of them — thousands of workers moved into the surrounding towns of Kilgore, Longview, Henderson, Marshall, Gladewater, and Tyler. With these came leasing problems, transportation headaches, "hot oil," proration difficulties and law enforcement problems—solved only by Texas Rangers and eventually by a declaration of martial law. Churches in Kilgore were used as detention halls for law violators.



Above is Bateman Drilling Company's admonition to questioning visitors. Laws were made by those who could enforce them—that is prior to the period of martial law, indicated at right. Many lease litigation cases were drawn out as much as ten years.

From an article concerning drilling practices in the East Texas Field in the April, 1931 issue of *The Petroleum Engineer*, comes this comment. "The major problem of both drilling contractor and producer is transportation. . . . This article being written during the rainy season, the roads have become almost impassable for trucks and only mule teams can be used for moving equipment from railroads to the fields. . . . In Kilgore one contractor has 800 head of mules and it is not uncommon to see as many as 60 head of mules hitched to one boiler."

Also in this article on drilling, written by Joe D. Hicks, Jr., of the Robinson-Hicks Drilling Company, is this statement concerning the multitudes of employed who have come for work. "Kilgore was forced to call on the Texas Rangers to get rid of the undesirable element. There were 11 Rangers in the town for 10 days, and during their stay, they banished more than 1000 people. . . . In one day the Rangers herded up a crowd of 100 people and drove them through the streets to the 'Church.' Here each was searched and questioned. If any had work, or a job in sight, he was released; others were ordered to leave or were taken to the county seat and placed in jail."

From mid-August until September 5, 1931, every well in the field was shut down to establish a well proration schedule. Crude at this time was valued at only 10 cents per barrel. By the middle of 1933 the field was producing nearly 1,000,000 bbl daily; 13 pipe line companies were moving 725,000 bbl of it and tank car shipments accounted for 175,000 bbl, while 41 refineries were processing at least 75,000 bbl daily.

The East Texas field has produced around 3.2 billion barrels of oil in the last 25 years, and is still averaging around 80,000,000 bbl yearly.

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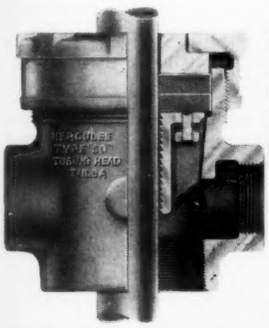

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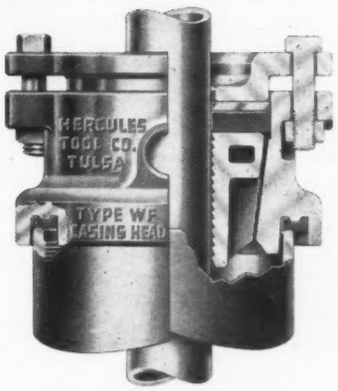

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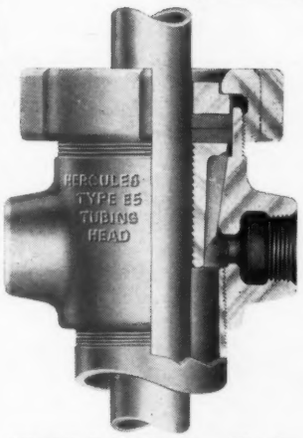

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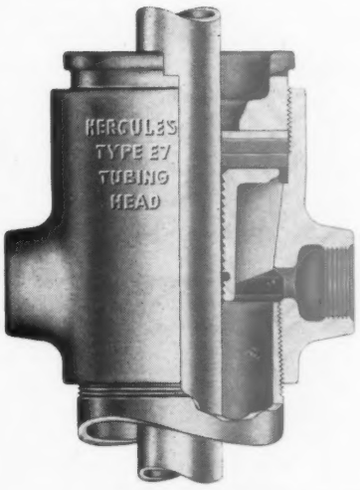

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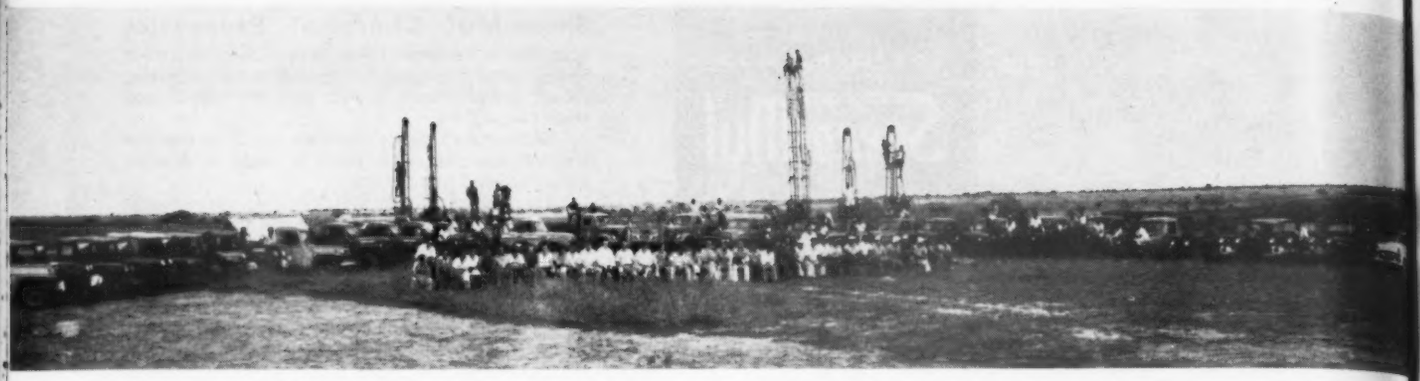

FIG. 1. Two complete seismograph parties assemble in Angola, Portuguese, West Africa, ready to go to work. Considerable work has been done getting this group and equipment on location; a great deal more is yet to be done.

What It Takes To Explore for Oil in Other Lands

Equipment, personnel, communications, transportation, regulations impose difficult problems in foreign exploration

Cecil H. Green
President of Geophysical Service, Inc.

BETWEEN the lines of legal wording on each agreement signed by an oil company and its geophysical contractor for work in a foreign country lies a host of problems for both of them. On the contractor's side, once he begins the actual placement of a domestic field party, he will be faced with problems of securing shooting permits, working and living conditions, instrument maintenance, vehicle licenses, transporation, and the like. Add to this a prospect that may be explored only partly by white men, where foot trails are the only means of ingress, where no English is spoken, and where malaria and dysentery are occupational hazards, and you approach the sum of the problems faced by seismic exploration crews on many foreign assignments.

Foreign seismic exploration is costly. It can also be quite profitable, for both the client and the contractor. For that reason, more and more oil companies are expanding into foreign work, and the contractors, profiting from the extra efforts they must exert, are extending their foreign operations.

Twenty-five years of seismic exploration experience has added much to solving problems that arise on every seismic survey. Each survey, however, has problems inherent to it alone, and so long as there are new areas to explore, new problems will arise.

Close cooperation between client and contractor accounts for solving many problems before they actually arise. In many instances in foreign work, the contractor receives invaluable information and help from the oil company that has an organization "on the ground." These oil company foreign offices are familiar with terrain and most of the problems that may be locally encountered in the entry and performance of seismic parties.

On some occasions, however, the contractor enters into the work without prior first-hand knowledge of the area and without the benefit of help from a regional client office. When this occurs, the contractor must assume responsibility for many details that normally are handled by the client's regional office. Securing entry permits for personnel and equipment is the first and most important phase of this additional responsibility. These details will also include securing shooting permits from individuals or governmental agencies, as the case may be, for, although the oil company will have gained concessions for exploration in the area, permits for the actual shooting are also required. Other permits may be needed for the importation of explosives and seismic equipment and for the use of radios.

Local labor laws also pose problems in many areas. Nationals are employed whenever possible. In most foreign areas, they are used as helpers on the field party. In Canada, field parties are composed almost entirely of Canadians and in Mexico nationals are used in every field party position. They assist the drillers, shooters, and recording unit, and perform various tasks in the field camp. In more remote areas, natioals may be employed as bearers for the equipment. A single seismic party, operating in mountain or jungle terrain, may employ as many as 500 to 700 nationals at one time. This presents a tremendous supply problem for the field party.

Field parties are carefully briefed on local customs and religion before being assigned to foreign work. A special effort is made to combat the U. S. attitude that wherever the American may be, he is not the foreigner.

Reports Tell Story

These excerpts from the operational diary of a gravity meter operator working in the Middle East point up some of the problems faced in that area of operations: "Had to swim three rivers today . . . weather miserable . . . rain most of the time. After metering seven stations, a storm caught us in mid-river, nearly capsizing boat. We had to return to bank and spend the night in the sampan, wet, cold, and hungry . . . the launch searched, but couldn't locate us until daylight. In planning work, local religious holidays must be taken into account. Communication with base camp quite difficult, takes

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FIG. 2. Special equipment is needed to operate in some countries where terrain imposes hardships, such as in Canadian muskeg country.

FIG. 3. Portable seismic crew in the marshes north of Vera Cruz, Mexico. Note inner tube at left used to float equipment.

FIG. 4. Saudi Arabian nationals serving as helpers on a seismic recording unit working the scorching deserts of Saudi Arabia.

FIG. 5. Barge and houseboat camped on banks of the Amazon River in Brazil serve as headquarters for geophysical party.

several days to receive answers to telegrams . . . although base camp is only 100 miles away."

Much of the seismic work done in Brazil is accomplished on the Amazon River and its tributaries. Camps are entirely composed of boats and barges. Houseboats serve as sleeping and mess quarters for the field party. In view of the fact that the prospect may be hundreds of miles from the nearest town of any consequence, the operation has to function as a self-contained unit. Due to silted conditions, debris, stumps, and snags, the mortality rate on seismometers is quite high. Work is performed by dragging the cable and seismometers behind the boats, and cables are subject to snagging. Therefore, a surplus of seismometers must be on hand, if operations are to progress without interruption.

The stock-piling of any equipment in the tropics, however, is a complicated and touchy operation. Each piece of metallic equipment—seismometers, drill parts and instruments—must be carefully oiled, wrapped, and stored to prevent corrosion. Condensers have to be sealed in air-tight containers, or they will not last for more than two months on a shelf in a shed on the Amazon. Since replacement parts may take two and three months to arrive from the United States, due to transportation difficulties and customs regulations, a party chief must be able to anticipate his needs months before they arise.

Although seismic equipment is built to withstand extremes of climate, it is necessary to keep a constant check on instruments by sending test records to the field service department of the home office at least once a month. These records are carefully checked by instrument engineers for any evidence of gradual instrument deterioration. If the records appear faulty, the field service department tries to determine the cause and then ships replacement parts to remedy the situation. If this method fails, the field party puts a spare set of instruments into use and the first set is sent back for repair at the home office.

Financial Picture

The financial side of the business is an all-important one to client and contractor alike, and although it may not present as many dramatic problems as are to be experienced in operations, it can present some quite complicated onces.

Since personal checks are usually not acceptable as tender on the Amazon or in the Gulf of Suez, it is imperative that adequate resources are available for the transmission of considerable sums of money to places quite remote from international trade cities.

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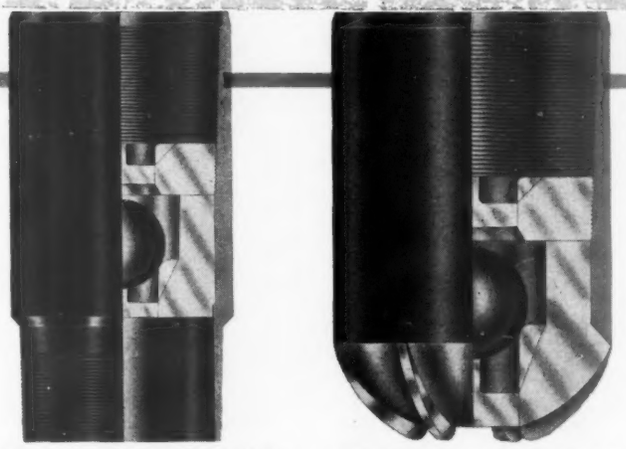

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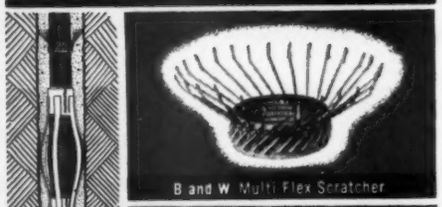
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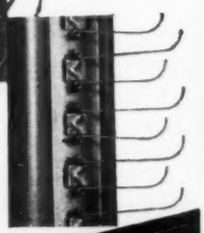
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Some time ago, the home office of a contractor received a cable from one of its field parties operating in a new location in South America. The message was clear enough... the party chief needed $5000, post haste, in order to purchase operating supplies. The address of the cable station to where the money was to be sent, however, was unintelligible. Tracing the cable would have taken too long, since the party location was nearly 100 miles from the nearest telegraph station. Working with representatives of a local banking firm, it was decided by the contractor's financial department that the party chief would have to call for the money at one of three locations in the area. In order to prevent tying up $15,000, the local bank contacted its foreign correspondent bank and arranged for agents in the three locations to authorize payment to the party chief. A deposit of $5000 was made, and when the party chief presented his credentials at one of the locations, the money was promptly paid. Agents at the other locations were notified, and the transaction was written off as another problem solved.

Currency fluctuations pose a constantly changing problem. Since field party men on foreign service receive a pre-set living allowance, it is necessary for the home office to be well versed on the current rates of exchange in order to keep living allowances at the plane agreed on in the contract. In the face of these obstacles, adequate receipts for expenditures are mandatory, and complete cash reconciliations are required in the home office by a set date each month.

Continuous operation in any one country can result in the accumulation of a considerable amount of that country's currency. When this occurs, the finance department must remain alert to the possibility of devaluation. Supplementary reading of newspapers and trade journals helps the department keep abreast of developments of this sort.

In most countries, field party personnel are subject to income taxes levied by the country. And the contractor is subject to corporate taxes, although no permanent office may be established in the country.

Since the client tells the contractor where he must work, the contractor can't choose the most advantageous situations for his personnel. In some countries, field party personnel face higher income taxes than they would face if they were working on a domestic crew. In these instances, the contractor must cushion the difference in the tax rate.

Personnel Problems

Personnel problems, as they relate

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to professional and technical people, must be handled in minute detail before the field party can leave the United States. A first and paramount step in manning a foreign crew is the careful selection of this personnel. Important qualifications are experience, education, temperament and proven ability on the job. In practically every case, the foreign assignee must have worked at his respective job for a year or more in the U. S. Details involve such things as passport requests, innoculations, physical examinations for each party member and each member of his family who may be accompanying him, legal assistance for the drawing of wills and powers of attorney, travel arrangements, and the packaging of household goods. Last, but far from least important, is the procurement of clearance from draft boards, for any party member eligible for service.

Once settled in a foreign location, the field party members must solve such personal problems as schooling for their children, arrangements for suitable housing, and the puzzle of how to make an electric razor work with 220 v.

Nationals employed as helpers also pose problems in housing and feeding. In some areas, caste and the existing social order necessitates the establishment of possibly two or more separate camps. Few of the nationals will accept paper currency, and this presents the difficulty of having an adequate supply of "hard" cash on hand for payday.

The conclusion of a survey doesn't conclude the contractor's problems. If the field party is not slated to begin work for another client in the same general area, all equipment and personnel must return to the U. S. and work of placing crew done in reverse.

Following one survey in Europe, a notice was received by GSI's Dallas office. It said that a shipment of seismic instruments was being detained at one of the port cities by the U. S. Department of Agriculture. Further inquiry brought out the fact that the instruments had been packed in straw and the shipment was subject to inspection for hoof and mouth disease. The entire shipment had to be unpacked, fumigated, and the straw burned before the instruments could be released.

These are only a few briefs on what it takes to transport seismograph crews into other lands and to make adequate surveys in the continuous search for petroleum structures. It is a job that takes not only technical know-how, but considerable patience and attention to the most minute detail. As long as there exist rewards for private capital to look for oil abroad, and so long as the political atmosphere permits, the search will continue. * * *

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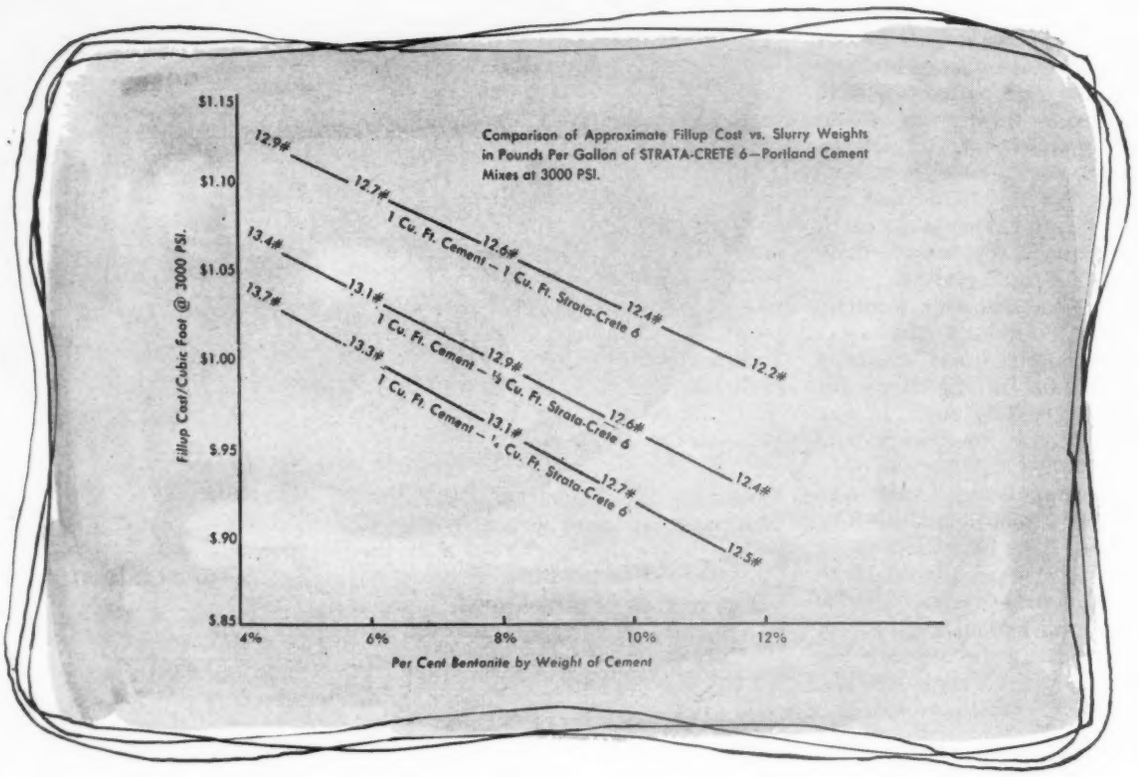

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XUM

EXPLORATION ACTIVITIES

LOUISIANA

★ Eighty miles southwest of New Orleans in Vermillion Parish, Monterey Oil Company has opened up a new gas and condensate field. The Monterey et al State No. 1, flowed 3,000,000 cu ft of gas and 125 bbl per day of 46 deg crude from perforations at 13,748-76 ft. Kern County Land Company holds an interest in the discovery. Both are prominent West Coast operators.

★ Gulf Oil has a producer on one of the over-water blocks leased from the Federal Government in October, 1954. The well is in block 154, Ship Shoal area of the Gulf, about 65 miles southeast of Morgan City, about 35 miles south of Terrebonne Parish coast line. On a ¼-in. choke, it flowed at a rate of 595 bbl of 29 deg oil per day with no water. Tubing pressure is 900 psi. Total depth of the well is 6919 ft. Perforations were made between 6196 and 6226 ft. A confirmation test will be drilled from the same platform which stands in about 55 ft of water.

★ First discovery well to be brought in by the "John Hayward" mobile rig of the Ocean Drilling and Exploration Company has been finaled for Shell. Shell's State Lease 2545 No. 1, in Block 16, flowed on a production test at a daily rate of 4,500,000 cu ft of gas and 45 bbl of 49.7 deg condensate under pressure of 3835 psi through 14/64-in. choke. The well was drilled to a total depth of 13,297 ft and production was from an interval of 12,315 to 12,330 ft.

TEXAS

★ The old Davis Hill salt dome, Liberty County—where efforts to bring in an oil field reportedly date back as far as 1905—has been successfully cracked by the Texas Company. Texaco's fourth wildcat, the Wirt Davis Estate No. 4, on a 17-hr test flowed at the daily rate of 185 bbl of 46.1 deg oil through a 10/64-in. choke from perforations, 6833-6843 ft. Tubing pressure was 850 lb and the gas-oil ratio, 720 to one. Total depth of the hole was 9106 ft. The discovery well, opening a new field, is 16 miles east of Cleveland, and is 12 miles south of Hardin field, nearest oil production.

★ D. D. Feldman Oil & Gas of Dallas has set casing on their No. 1 Vela approximately 2 miles west of the Garcia field on the V. C. DeVela lease—a new discovery in Starr County. On drillstem test, gas came to the surface in one minute having 555 lb pressure built up in seven minutes. Two additional sands with oil or gas possibilities are behind the pipe and untested. On initial test, the well flowed 27,000,000 cu ft of gas per day through perforations at 3184-87 ft.

★ Sunray Mid-Continent is now drilling the No. 1 Vela confirmation test to its No. 1 Ramon, Jaboncillos Creek field opener LaHuerta Grant, A-27 Duval County. The well, located on a 2000-acre block, will seek production from the 3100-ft Frio sand, which produced at the rate of 107 bbl of 23 gravity oil per day from Sunray's discovery well completed in late June. Approximately 5600 ft southwest of the Sunray well, the Morgan No. 1 Parr-Moffett is now drilling below 2000 ft. This well will have an important bearing upon the extent and direction of the new field.

★ Hickey and Randall almost called the No. 1 Sindey A. Johnson dry 50 ft too soon. After the well had been shut down several days at 10,025 ft, the operators decided to deepen with a resulting good show from an unidentified basal Pennsylvanian sand below the Cordell zone. On drillstem test run at 10,038-075 ft with tool open one hour and 45 minutes, there was a strong blow immediately with gas-to-surface time given as 55 minutes. Recovery was a 2000-ft water cushion plus 4450 ft of free oil and 30 ft of oil-cut mud with no formation water. Location is near Pottsboro, Grayson County.

★ In Orange County the Meredith & Company No. 1 Miller-Vidor, a mile north of and across a fault from North Vidor production, was completed as a successful gas condensate discovery. It initialed 12,000,000 ft of gas per day plus 30 bbl of condensate from the Hackberry sand at 7232-47 ft.

CUBA

William B. Duce and Associates of California have started a wildcat oil well on the Esperanza concession in the Jaruco area of Havana Province, Cuba. The well is near the town of Galafate and about 600 ft from another well that reportedly had good shows of oil.

SUMMARY OF DRILLING ACTIVITY FOR JULY
(As Compiled by Rinehart Oil News Staff)

States	New locations		Wildcat completions			Field completions			Junked & abnd.		Temp. abandoned		Abandoned locations		Current active wells	
	Wc	Field	Oil	Gas	Dry	Oil	Gas	Dry	Wc	Field	Wc	Field	Wc	Field	Wc	Field
Alabama	5	0	0	0	2	0	0	0	0	0	0	0	1	0	3	0
Arizona	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Arkansas	12	54	1	0	5	43	1	14	0	1	0	0	0	0	15	43
Canada (Williston B.)	14	92	0	0	8	40	1	4	0	0	0	0	0	5	18	25
Colorado	80	63	2	2	59	18	5	14	0	0	0	0	2	1	56	66
Florida	2	0	0	0	4	0	0	0	0	0	0	0	0	0	6	0
Georgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Idaho	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kansas	90	266	15	6	73	134	17	83	0	0	0	0	3	3	75	336
Louisiana	65	259	4	3	39	176	38	48	0	3	1	3	0	7	97	251
North	30	119	0	0	17	85	11	20	0	0	1	0	0	4	16	51
South	29	123	2	1	21	78	25	28	0	2	0	2	0	3	62	176
Offshore	6	17	2	2	1	15	2	0	0	1	0	1	0	0	19	24
Mississippi	12	19	1	0	10	16	2	7	0	0	1	1	0	2	13	17
Montana	30	22	2	0	13	10	0	3	0	0	0	0	2	1	30	34
East	1	13	0	0	0	4	0	0	0	0	0	0	0	0	9	16
West	29	9	2	0	13	6	0	3	0	0	0	0	2	1	21	18
North Dakota	9	18	0	0	4	12	0	2	0	0	0	0	0	0	10	14
Nebraska	34	52	4	0	38	14	0	13	0	0	0	0	0	0	18	46
Nevada	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
New Mexico	23	130	1	6	15	74	46	7	0	0	3	5	1	4	66	193
Eastern	9	63	1	0	10	74	4	6	0	0	3	5	1	4	36	119
San Juan	14	67	0	6	5	0	42	1	0	0	0	0	0	0	30	74
Oklahoma	60	531	7	6	48	396	29	141	0	0	1	0	0	7	80	473
South Dakota	6	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Texas	540	1,430	68	14	341	918	71	224	0	1	8	15	17	76	437	988
East	36	44	0	1	26	26	17	9	0	0	0	0	0	5	22	72
Gulf Coast	37	110	2	1	34	63	10	18	0	0	1	2	1	5	37	100
North Texas	147	436	23	3	69	269	1	87	0	1	0	0	3	11	72	120
Panhandle	8	80	0	1	8	37	18	3	0	0	0	0	0	6	10	55*
South Texas	102	282	7	7	71	142	20	38	0	0	7	6	4	14	60	84
Offshore	1	0	0	0	1	0	1	0	0	0	0	0	0	0	4	1
Border Co.	24	59	4	1	15	61	0	10	0	0	0	1	0	3	28	65
West Central	117	141	24	0	79	75	3	42	0	0	0	1	9	25	55	46
West Texas	68	278	8	0	38	245	1	17	0	0	0	5	0	7	149	445
Utah	8	1	1	1	4	0	0	1	0	0	0	0	0	0	28	3
Wyoming	33	83	4	0	16	23	0	14	0	0	0	0	0	2	52	83
Totals: Jan.	766	2,636	108	31	673	1,618	197	479	4	2	14	14	26	85	878	2316
Feb.	798	2,931	93	30	630	1,745	144	548	4	7	17	22	34	126	877	2402
March	1040	3,535	91	41	674	2,133	219	623	4	11	16	26	19	107	863	2534
April	957	3,135	111	19	556	1,819	159	525	6	4	8	28	9	102	882	2551
May	1030	3,245	91	21	637	1,926	234	626	2	1	22	28	11	80	942	2588
June	1151	3,392	125	52	735	2,134	213	658	5	5	16	24	19	94	1017	2588
July	1024	3,030	110	38	689	1,876	210	575	0	5	14	24	26	108	1010	2572
1955 Total	6766	21,904	819	232	4594	13,251	1376	4034	25	35	107	166	144	702	—	—

* Figure Incomplete.

'Way out in West Texas where the big core grows, Core Lab has put into service a fleet of *Freeze Trucks.* Completed only recently, these sparkling new dry ice units are already in great demand.

In 1949, before the advent of widespread diamond coring with routine recovery of up to fifty feet of large diameter core, Core Lab inaugurated its Frozen Core Service with the now-familiar Freeze Box. A supply of dry ice soon became standard "equipment" in each local lab.

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Exploration

MONTANA

★ Sunray Mid-Continent Oil Company has staked location and spudded in to drill its Hauk No. 1 in Rosebud County. The new well is projected to 5500 ft for an Amsden-Heath sand test. It is in the area of the northwest Sumatra field where average oil production sand thickness averages approximately 70 ft. The exploratory well is located on a 640-acre farmout lease from the Flank Oil Company, of Billings and Great Falls, Montana.

★ Testing is continuing at Union Oil's No. 1 Morning Gun, near East Glacier, west of Cut Bank on the Mountain Front. Recovery of high quality condensate has been encouraging at the highly-touted sweet gas well. Around 4000 gal of acid were used through 120 perforations at a depth of 8992-8960 ft, and about 2000 gal was run in 40 perforations in the interval 9000-9060 ft. On initial test, the well flowed at the rate of 6,000,000 cu ft daily with calculated recovery of 249 bbl of condensate from the Madison lime. Operators ran 5½-in. casing to 9381 ft, then cored below the pipe to 9559 ft and later plugged back to 9295 ft. Top of the Madison was called at 8956 ft.

NEW MEXICO

★ Sunray Mid-Continent Oil Company and associates have opened a new oil pool in Lea County at their wildcat, No. 1 O. E. Fulton, approximately 3½ miles southeast of the Gladiola pool, site of the nearest production. The well flowed at the rate of 942 bbl of oil a day in a 12hr test through a ½-in. choke. The well started flowing following perforations in the Pennsylvanian lime at 9688-9698 ft and 9705-9714 ft. The well was drilled to a total depth of 12,320 ft to the Devonian lime but proved dry at that depth and was then plugged back to the Pennsylvanian, perforated, and washed with 500 gallons of mud acid. Tubing pressure was 325 psi. Plans are under way to drill a southeast offset.

★ In Rio Arriba County, Skelly Oil Company is testing its Jicarilla C No. 1 two miles northwest of production on the Blanco trend. On drillstem test of the Dakota at 7090-7290 ft, there was a blow of gas with recovery of 950 ft of free oil and 70 ft of oil-cut mud. Casing was set on bottom at 7400 ft and perforated at 7110-30 ft with a show on test of 6,000,000 cu ft of gas with some condensate. Additional testing is continuing.

★ Sunray Mid-Continent Oil Company is currently rigging up on New Mexico State "G" No. 2, a confirmation test to the company's New Mexico State "G" No. 1, which extended the E. K. Queen field in Lea County. The new well will seek production from the 4300-ft Queen Sand. In the "G" No. 1 wildcat this sand potentialed 144 bbl of 32 deg oil on a 12/64-in. choke. Location has been staked on a 1320-foot east offset to the "G" No. 2 well which is presently rigging up.

OKLAHOMA

★ Sterling Oil of Oklahoma, Inc.'s No. 1 Rogers well in Garfield County, has been completed in the First Wilcox sand. The oil string, 5½-in. casing, was run to 6217 ft and cemented with 100 sacks of cement. Mechanical difficulties delayed the completion for a month but after perforating from 6100 to 6122 ft the well commenced flowing at the rate of 164 bbl per day, natural. The Oklahoma Corporation Commission has given a special temporary testing allowable of 150 bbl per day for 30 days to the new pool opener. The Mississippi lime zone, from which Sterling has 16 producing wells to the south, is also present in this well and possible dual completion is contemplated.

ARIZONA

★ Humble Oil and Refining is planning a series of wells in the northeast corner of the state. The first wildcat, the No. 1 Navajo Tribe of Indians, is about a mile southwest of Shell Oil's East Boundary Butte discovery in Apache County. The initial test was spudded early in August, and unconfirmed reports that oil shows were encountered in the Pennsylvanian topped at 4182 ft.

NORTH DAKOTA

★ The Texas Company is completing another likely pool opener at its No. 1 Government M. S. Pace, in northern Billings County. Location of the well is 25 miles north and five miles west of the Fryburg pool, site of the nearest production. Well swabbed oil and black sulfur tasting water on a test of the Madison at 9743 ft, plugged back depth. Largest amount recovered totaled 14 bbl of oil with 59 bbl of water and an ungaged amount of gas.

★ Texaco's No. 1 A. Helle flowed at the rate of 384 barrels of oil per day through a 24/64-in. choke from perforations 9290 to 9302 ft, 9320 to 9334 ft and 9369 to 9386 ft in the Madison limestone, to open up a new field in McKenzie County. The new well is seven miles southeast of Keene field and eight miles southwest of Sanish field.

★ Lion Oil Company has scheduled a confirmation test of its No. 1 Skarphol in the new North Souris field of Bottineau County. The second well, to be located east of the discovery, is the No. 1 Carl. The first well was completed for 100 bbl of oil per day on pump.

CANADA

★ In the South Stony Plains area of Alberta, a discovery well has been completed by Royalite-Canadian Gulf-Devon companies. The Leduc No. 1 flowed at a rate of 405 bbl per day of 38 deg crude. This southward extension of the Stony Plains field, completed on a unitized block of 3200 acres, would appear to prove up locations for a large number of additional wells.

UTAH

★ Gulf Oil Corporation's No. 1 Coalbed Canyon in eastern San Juan County has recovered gas at a rate of 13,900,000 cu ft per day in a 2½-hr test, with 27 bbl of condensate. Further testing is being delayed pending installation of a gas-oil separator. An early test of the Paradox section of the Hermosa gaged a flow of 8,980,000 cu ft of wet gas a day. Wildcat is 13 miles southeast of Monticello.

PERU

★ Richfield Oil Corporation and Peruvian Pacific Petroleum Company, subsidiary of Cities Service Company, have reported their test well in the Tunal area, on a northwest coastal zone concession in Peru, recovered oil at a rate of 760 bbl per day during a 70-minute formation test. The operators recovered 30 deg oil on the test from an interval between 5854-5891 ft. The well is located approximately 10 miles east of the town of Lobitos and about 6 miles from other production.

CALIFORNIA

★ The Texas Company plans to drill a wildcat in Northern California's Humboldt County. The company will explore in the Table Bluff area with Quinn No. 1. About three years ago, Texaco drilled a 6110-ft test on Holmes-Eureka lease in the Hydesville Nose area, but the well failed to produce. Only one well was drilled in Humboldt County last year, a 3022-ft dry hole put down by Richfield Oil Corporation on the Graham lease near Petrolia.

★ Shell Oil Company has staked location for a deep test southeast of the South Cuyama field in an area where several other operators have drilled unsuccessfully in previous years. The new try is to be Heller No. 22-23 four and one-half miles southeast of production in the field.

★ General Petroleum Corporation is prospecting ahead below 13,500 ft in the deepest well yet drilled in the Sacramento Valley. The well is located in Yolo County, about 10 miles southwest of the state capital. A 7⅝-in. protection string has been set to 13,100 ft and the company plans to carry the exploratory well to about 15,500 ft.

CALIFORNIA

★ Oceanic Oil Company has commenced drilling a wildcat one mile southwest of Fellows in the Midway-Sunset field. The well, CWOD No. 2-6, is expected to explore to a depth of about 4800 ft. It is located 900 ft south of a 4816-ft duster the company drilled last fall.

★ In the Midway-Sunset field, Oceanic Oil Company is drilling the deepest test yet drilled in that field. CWOD D-3-7 is prospecting ahead below 12,000 ft looking for Eocene sand. Oceanic is expected to take the wildcat below 15,000 ft.

★ Standard Oil Company of California, as unit operator, is preparing to drill a new Carneros test in Naval Petroleum Reserve No. 1 at Elk Hills. The new Carneros test, designated UONPR No. 538 19R, will occupy a normal "38" location on Sec. 19, 30-23. Only one other Caneros well has been drilled since the discovery well, completed several years ago for 200 bbl per day of condensate from 9300 ft.

★ O. M. Slosson is drilling Norris et al-KCL No. 1 in the Greeley field, Kern County. A Stevens test, the well is expected to explore to about 8000 ft.

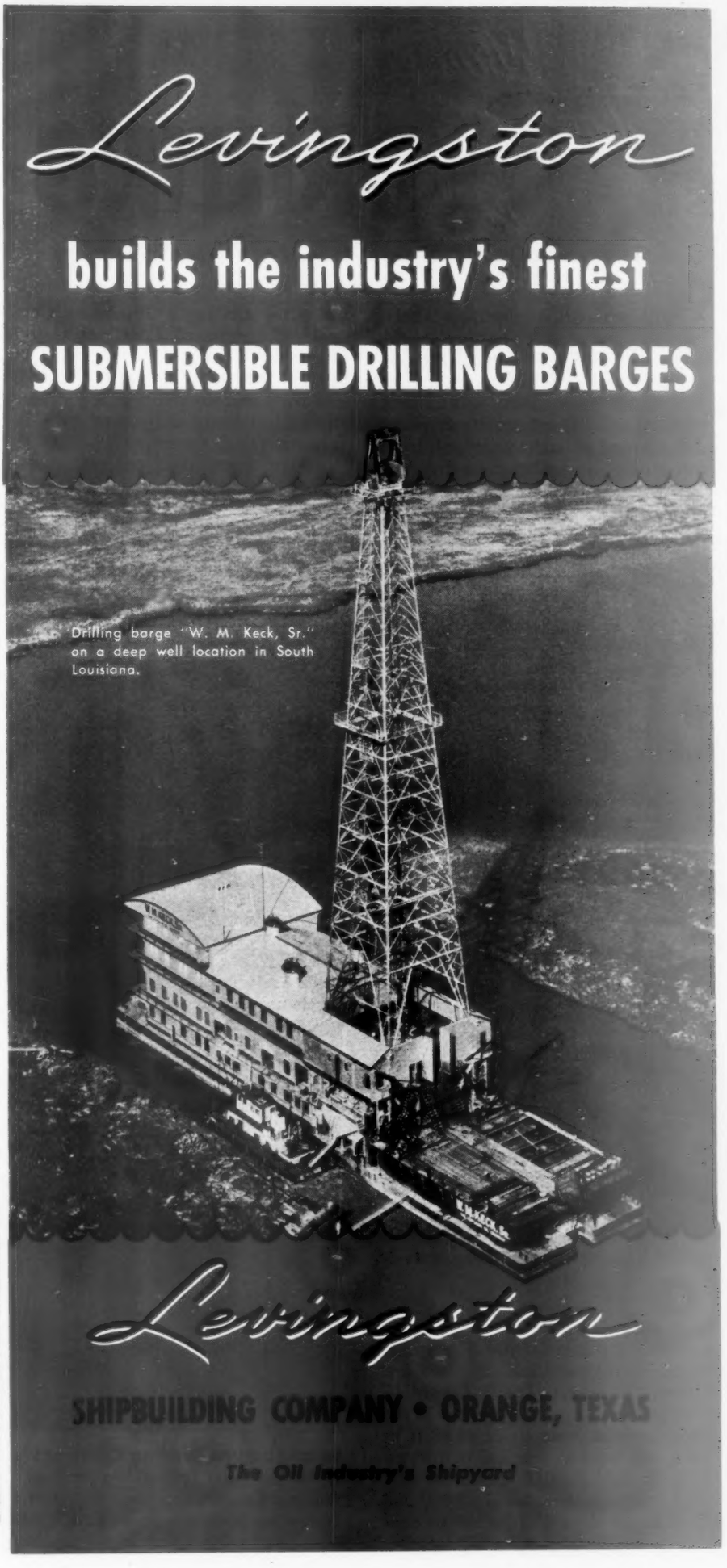
★ Moriqui Exploration Company has leased several thousand acres from Kern County Land Company in the Famoso area, 20 miles north of Bakersfield and plans to explore for new production in that area. The first test will look for Vedder and Famoso sands with a projected depth of around 7200 ft.

★ Federal Oil Company has made a new fault block discovery in the Raisin City area of Fresno County. Noble No. 24 was completed flowing 300 bbl per day of 30 deg oil. The well was drilled to a total depth of 6400 ft on a 1400-acre block, and an offset is currently drilling.

★ Shell Oil Company has staked location for a new wildcat near Simmler in the Carrizo Plains area. The well will be Stauffer No. 41-24 in San Luis Obispo County. The location is northwest of a deep test the company drilled several years ago on the McDonald estate, which recovered a small amount of high gravity oil from below 8000 ft, but which failed to make a commercial well.

★ Richfield Oil Corporation has spudded a test in the Santiago area southeast of Maricopa and the Midway-Sunset field, Kern County. Leutholtz A No. 19 is scheduled for a depth of around 3400 ft.

★ At the northern edge of Race Track Hill field, Fletcher, Bysshe & Barratt are drilling Cohn No. 41-A, a 4700-ft Jewett and Pyramid Hill sands test.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What's doing in DRILLING

★ With exploration expenditures being restudied by most operators, reentry into abandoned wells is receiving considerable attention into every drilling program in United States and Canada. Old logs and cores from dry holes are being dusted off and reanalyzed; likely formations—passed up in the first drilling cycle—are being tested; new treatment is being given tight formations. Deepening of the old wells is also proving profitable in expanding the operator's drilling dollar.

★ Much sought after Hart production in and around Garvin County, Oklahoma, is the site of many of the reworked wells. Viersen & Cochran Drilling Company has been busy for Superior Oil Company, and Portable Drilling has contracts with An-Son Petroleum. Trigg Drilling Company is drilling ahead toward a Hart objective for Phillips Petroleum.

★ Superior has successfully completed its No. 1 Magee in the West Lindsay field of Garvin County in Oklahoma. Cities Service originally drilled the well in 1951 to a depth of 8551 ft. Superior made a 55 bbl per day flowing producer through perforations at 8114-51 ft and 8260-67 ft in the Hart.

★ Jake L. Hamon has reworked an old Carter Oil duster into a Hart producer in the same county. Operator obtained flowing production from perforations at 7656-68 ft. The well, No. 1 Tucker-Freeman, did 91 bbl per day through a 20/64-in. choke. Hamon also retrieved 91 bbl per day from perforations into the Gibson sand at 7634-46 ft, and is eyeing the possibility of dual-producing the "dry hole."

★ Mobil Producing Company has reworked a dry hole to open a new zone in the Manderson field in Big Horn County, Wyoming. The No. F-14-12 Government, originally plugged in the Phosphoria at a depth of 8135 ft in 1953, was worked over and perforated in the Muddy at 6019-57 ft. The well, after being acidized, tested 10,000,000 cu ft of gas daily and 14 bbl of condensate per hour.

★ Crow Drilling & Producing Company of Shreveport, Louisiana, is drilling below 12,170 ft on the old H. R. Bryant No. 1 for David Crow, Individual. Company's Rig 16 is redrilling a well originally abandoned by Continental Oil Company in 1947. In reworking operations, contractor was successful in washing to approximately 9500 ft—the bottom of old hole—after drilling out plugs.

★ New completion techniques have aided the drilling contractor—just as the redrilling programs have allowed additional capital for exploration. According to Stanolind Oil and Gas, 2000 new wells have been drilled as a result of hydraulic fracturing in the Caddo and Pine Island fields of northwestern Louisiana alone. Stanolind has drilled 42 of these new wells and have scheduled many more into the notoriously tight Annona chalk found in that area.

★ In the southern part of that state, a newly organized firm, that of George C. McGhee's McGhee Production Company will soon be carrying on geophysical evaluation and exploratory drilling. McGhee has recently opened offices in the Republic National Bank Building in Dallas, Texas.

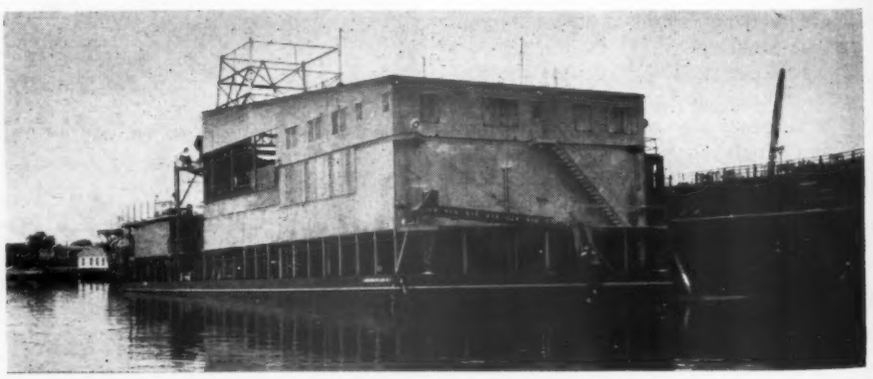
★ Also moving into Louisiana marshlands is a brand new U-1220 Unit Rig belonging to Chance Drilling Company, Inc. of Houston, Texas. Reports are that the new rig, capable of 12,000 to 20,000 ft drilling, will be put to work for Atlantic Refining.

★ Louisiana offshore drilling plans are soon to be announced by Southern Production Company, Inc. of Fort Worth, Texas. The firm recently acquired most of the north half of Block 102 in the Vermillion area of the outer Continental Shelf. The lease, acquired by a high bonus bid of $3,050,000 during the last federal auction, is situated in 68 ft of water. Although this is Southern's first tidelands lease venture, the company owns 51 per cent of the Offshore Company of Baton Rouge, Louisiana, well known among the sea-legged drillers.

★ A group of these Louisiana drillers and their crews has moved up north to display their deep-drilling techniques on a specially-constructed rig at the General Motors Powerama. "The world's fair of power," as it is called, is being held during the month of September in Chicago, Illinois.

★ A Chicago firm of Max Pray and Associates were completing the deepest oil producer in the state of Oklahoma. Max Pray's No. 2 Billy, in the Southwest Bradley area of Grady County, flowed 612 bbl of oil on initial test from perforations at 14,066-076 ft and open hole at 14,131-209 ft. The well is being completed at this depth in the Tulip Creek. The 7-in. casing was set at 14,134 ft and well was bottomed 14,209 ft. On drillstem tests, the well flowed from the Bromide at 13,828-90 ft and 13,941-56 ft. Warren-Bradshaw Explorations, Ltd., had drilling contract on the hole.

★ Deepest producer in New Mexico has been finaled by Sinclair Oil & Gas. The No. 1 J. P. Dean, drilled as a



Southeastern Drilling Company's drilling barge No. 21 has just been completed in the Levingston Shipbuilding yards at Orange, Texas. To be used in drilling operations in South America, the barge is of the steel-slotted submersible type. The 200 by 54 ft vessel is equipped with a No. 96 Oilwell drawworks powered by three GM quad diesel engines. The barge will provide quarters for 14 men.

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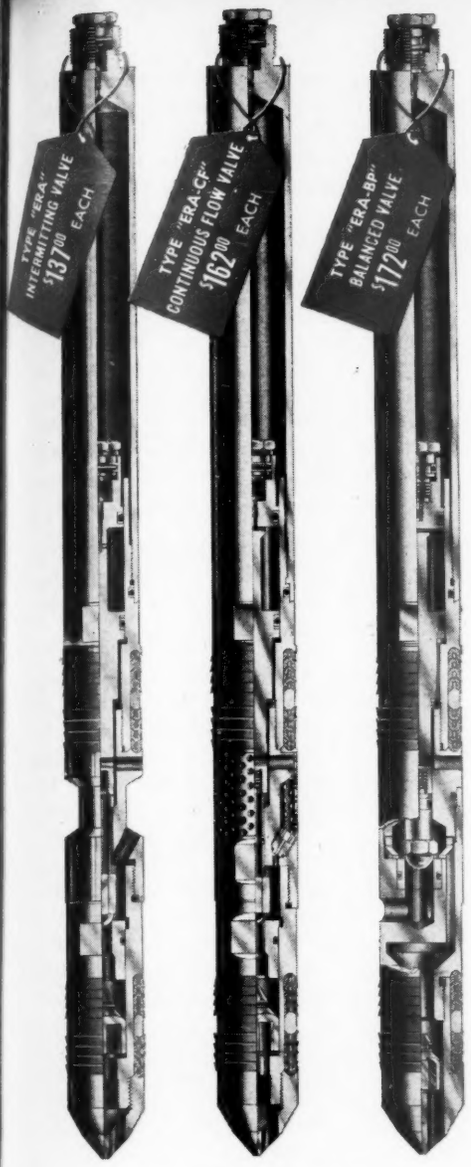
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FOR STANDARD MANDRELS

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wildcat four miles southeast of the Caudill pool and seven miles southeast of the Denton pool in Lea County, was completed as a flowing well from the Devonian. On potential test of perforations between 13,600-725 ft, the well showed a calculated daily flow of 2354 bbl of 53.6 deg oil through a ½-in. choke. Gas-oil ratio was 140 to 1. Tubing pressure was 300 lb and casing pressure was 260 lb. The well had already established production during a drillstem test of perforations in the Pennsylvania-Strawn at a depth of 11,480-530 ft, where oil flow gaged 25 bbl per hr. Completion in the Devonian would establish the deepest production anywhere in Sinclair operations.

★ Pergeo, a Milan, Italy drilling contractor, in cooperation with Itag, is well underway on a very deep test (for Europe) for Pontina Metano S.P.A. The well, the Rome 2, is scheduled to go to 9800 ft and is located at the Via Aurelia, 22 miles north of Rome.

★ U. S. Navy has announced discovery of a new gas well at Point Barrow, Alaska, drilled by crews of A. D. Rushing, Inc. The well, located on the Navy's Petroleum Reserve No. 4 near the Arctic Ocean, will provide gas for servicemen stationed in the Far North. Reports are that the Interior Department is planning to open up more than 20,000,000 acres near the find for public leasing soon. The government, in its program, found gas and some oil.

★ Oil has been found in the Western Desert of Egypt that is said to compare in density with that produced in Saudi Arabia. The find, made by the American Egyptian Company, was from a depth of 5000 ft in Burge al-Arab. Oil previously found in Egypt, in the Sinai and Eastern Desert area, are of low gravity. Offshore in the Gulf of Suez, the National Petroleum Company is conducting its exploratory ventures.

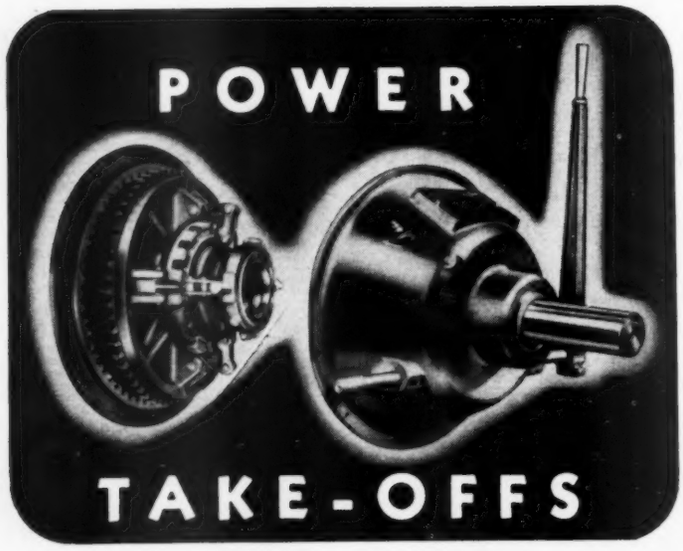
★ On the nearby southern coast of Arabia, in Dhofar, Drilling and Exploration Company, Inc., has a well underway for Cities Service.

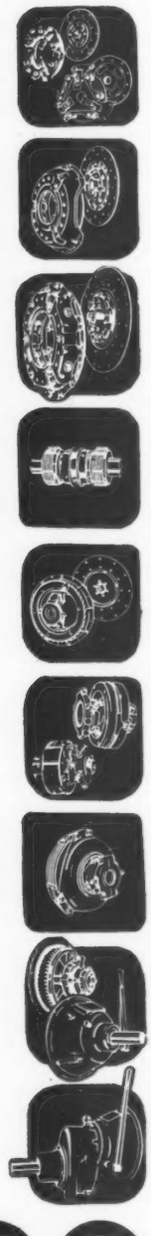
★ Standard of California is planning to explore offshore leases held by Coastal Caribbean Oils, Inc. along the coast of Florida. Geophysical work and drilling will be carried out over a 11-year period on the company's 4,500,000 acres between Apalachicola Bay southward to Naples on the west coast of that state. Also included in the deal are some 450,000 acres on Lake Okechobee and several other Florida lakes. Standard of California plans to spend $10,000,000 to carry out the agreement.

★ An extensive offshore program is being planned on five square miles of submerged tidelands off Newport Beach, California by several California companies. Offering a bonus bid of $3,333,533, Montery Oil, Humble, and Seaboard plan to sink wells offshore at the mouth of the Santa Ana River on a two-square-mile tract. Another similar tract, seaward of the first, picked up for a bonus of $1,333,533, will be explored by the same group, while Richfield, Hancock and Signal Oil companies have combined to take a third section on a bonus bid of $516,776. This area lies eastward along the coast. covering one square mile. Drilling is being permitted either by means of slant wells drilled onshore or from islands built in the ocean on tracts leased from the state.

★ Of interest to the California drillers is a rotary exploration drill for use in water well, geophysical exploration, and shot hole drilling. The "rig" is the ultimate in portability, as it may be moved in the back of a car, set up in 10 minutes, and weighs only 125 lb. The unit carries its own 9-hp power plant for rig power and air compressor, and is capable of depths of 100 ft. American Percussion has developed the drill.

ROCKFORD





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CLUTCHES

★ The Russians say they are nearing perfection of a turbine drill that has cut normal drilling time of 150 to 200 days to 20 to 40 days in the eastern oil districts of the Soviet Union. The news was disclosed in a composition released during the recent World Petroleum Congress. By the turbine method (introduced by the Russians in 1925, they say) drilling costs have been reduced three-fold. Reports say that in the oil district of Tuimasa the drilling of a 5900 ft well took no more than 100 to 120 hours using tri-cone bits.

★ A new conventional rotary rig has been added to the fast-growing Wes-Tex Drilling Company of Abilene, Texas. The firm, which now operates three units in West Central Texas, boasts of consistent drilling with no downtime since the company was organized. That record is hard to beat.

★ Green & Heiser Drilling Company has just finaled its one-hundredth well since going into business in Bakersfield, California three years ago. Well No. 100 was for Reserve Oil & Gas, and was completed as a possible extension of Bee Hive Bend production. The well is the Reserve—E. W. Pauley No. 71-33, finaled in the JV sand at 3650 ft, and was first considered a new pool discovery.

Rotary Rigs Operating in Oil Fields of United States and Canada*

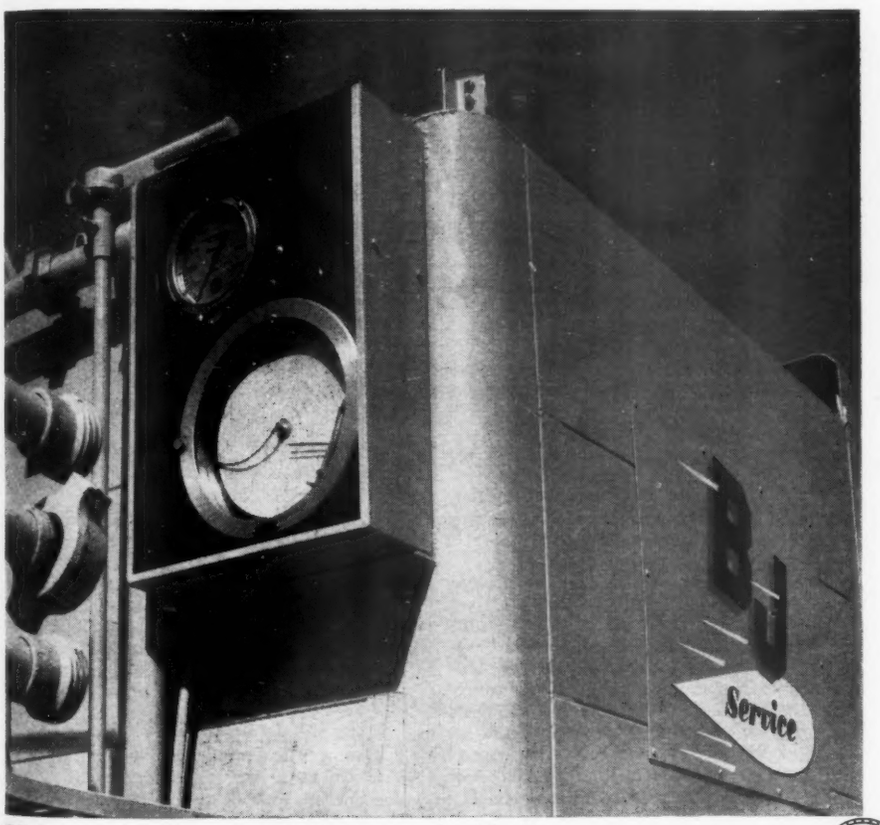
	July 11	July 18	July 25	Aug. 1	Aug. 8
Pacific Coast	145	144	144	143	142
Oklahoma	320	319	339	318	333
Kansas	173	171	179	172	179
Rocky Mountains	279	290	300	304	300
Canada	209	205	216	218	212
Ark-La-Tex	156	153	165	165	170
West Texas and New Mexico	537	527	515	520	532
Gulf Coast	593	586	585	586	598
Illinois	148	155	136	144	157
North Texas	330	336	331	329	328
	2890	2886	2910	2899	2951

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company

★ El Dorado, Arkansas, has the lease hounds jumping as the result of a well being completed near Citronelle, Mobile County, Alabama. The No. 1 Donovan, was drillstem tested at a depth of 10,900 ft. With tool opened less than 10 minutes, test showed 1800 ft of oil in drill pipe. Drilling crews were last reported coring ahead. Nearest production is 50 miles away. Ownership in the well is shared by Brooks Drilling and Everett Eaves, a geologist.

★ Frank Roberts, toolpusher for Crag Drilling, Ltd., has a good story to tell for a long time to come. He was asked to pick a site, any site, to drill for Orbit Oils to fulfill a commitment on a lease from the Saskatchewan, Canada, government. Roberts was driving from Cypress Hills to Maple Creek when he spotted a level spot through an open gate. After deciding that it would be a spot for easy drilling and would meet the requirements, he flagged the location and in due time started drilling.

★ The well was officially named the Maple Creek No. 1, and is located 24 miles west northwest of the Dollar field. The well opened 14 ft of pay in the highly productive Jurassic, then was drilled 32 ft deeper and entered the Madison limestone. It is said that the Mississippian which it passed on the way down, also will be productive.



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To obtain more information on products advertised see page E-43

RUNNING TOUR with MEN in the INDUSTRY

John Ed Cooper of Midland, Texas, has joined the B B M Drilling Company of Houston as assistant to the president. For the past nine years Cooper has been senior vice president, sales manager, and member of the board of directors of The Western Company. While in Midland Cooper was a member of the City Council and Board of Directors of the Chamber of Commerce as well as being active in other civic groups. Last year he served as vice president for West Texas of the southwestern district of API, division of production.

Pan American Producing Company announces a number of staff changes affecting its South Louisiana exploration organization, which is headquartered in Lafayette. **Kenneth R. Johnson,** geologist, has been promoted to senior geologist. **Ward A. Whitehorne,** associate geologist, and **Hamilton C. Perkins,** junior geologist, have been promoted to geologist, while **Coerte A. Voorhies,** junior geologist, has been promoted to associate geologist.

John W. Bell, associate geophysicist, of the Houston office, has been promoted to geophysicist and transferred to the Lafayette organization. **Charles W. Pirkey,** junior geologist, previously in Pan American's Shreveport office, and **Richard H. Hewitt,** associate geologist, of the Houston office, have been transferred to Lafayette.

Jo Pat Black, former assistant to the president of the American Republic Corporation, has opened his own geology and geophysical consulting business with offices in the San Jacinto Building, Houston, Texas.

J. P. Black

Black started his career in the field of geophysics in 1926 as a geophysical interpreter for the Calcasieu Oil Company. He later worked for a while in Mexico and joined Republic Production Company in 1934 in charge of their geophysical department. Following the merger of Republic into American Republic he became manager of the geology and lease division. He served as assistant to the president from 1952 until last year when American Republic Corporation was bought by Sinclair. At that time he was also president of Republic Production Company of Texas, a subsidiary of the corporation.

W. G. Moriarty has been promoted from assistant division superintendent of Magnolia Petroleum Company's Gulf Coast producing division with headquarters at Houston, to division superintendent of the Oklahoma Division with headquarters at Oklahoma City. In that position he succeeds the late **C. F. Stephenson. R. W. Lewis** has been advanced from assistant district superintendent of the Kermit producing district to assistant division superintendent of the Gulf Coast division with headquarters at Houston. **K. L. Nelson** has been promoted from production foreman at Kermit to assistant district superintendent there.

Cecil M. Rhodes has been transferred from the Louisiana Gulf district to the Natchez district as assistant district superintendent with headquarters at Natchez, Mississippi. He has been succeeded by **Thomas E. Wright** as assistant district superintendent at Morgan City. **Cyrus O. Turner** has been made assistant superintendent of the Chase, Kansas, district with headquarters at Great Bend. **Victor C. Bathtel** has been promoted from assistant foreman to production foreman in the Chase, Kansas, district.

Carl E. Hardaway has been advanced from assistant foreman to production foreman in Magnolia's Brownfield, Texas, district.

Marvin R. Hanks, gang pusher in the Kermit district, has been promoted to assistant foreman in the Brownfield district. **Thomas A. Flowers, Jr.,** has been advanced from assistant foreman in the Natchez district to production foreman in the Louisiana Gulf district with headquarters at Morgan City. **William John Wranosky** has been transferred from the Falfurrias district to the Louisiana Gulf district as production foreman. **G. W. Walker** has been promoted from assistant foreman to production foreman in the Falfurrias district.

In the petroleum engineering department, **Luther W. Randerson,** who has been senior petroleum engineer in Magnolia's West Texas division with headquarters at Midland, has been promoted to section chief in charge of drilling engineering and drilling mud control and transferred to the company's general offices in Dallas. **William N. Smith,** petroleum engineer assistant at Kermit, has been transferred to the Natchez district with headquarters at Natchez, Mississippi.

R. M. Churchwell, The Ohio Oil Company's division petroleum engineer at Casper, Wyoming, has been appointed assistant chief petroleum engineer and will be located in the general office at Findlay, Ohio. **L. C. Powell,** division petroleum engineer at Terre Haute, Indiana, will succeed Churchwell as Casper division petroleum engineer. **R. N. Ayars,** assistant division petroleum engineer at Houston, Texas, will move to Terre Haute as division petroleum engineer.

C. W. Stephens, formerly division petroleum engineer in Ohio's Los Angeles division, has been appointed senior petroleum engineer and is being assigned special duties by the division manager. **W. B. Emery, II,** petroleum engineer at Bakersfield, California, has been named Los Angeles division petroleum engineer succeeding Stephens.

Jesse R. Moser, has opened a private consulting office at 3721 Chippewa Drive, Detroit 21, Michigan. Moser is a graduate mechanical engineer and also a registered professional engineer. He has specialized in hydraulic applications to many kinds of mechanical devices for the past twenty-seven years. For several years he was special projects engineer to the general manager of Vickers Incorporated and is now retiring as executive engineer. He has been instrumental in the invention and development of hydraulic pumps. His first hydraulically operated, fully counterbalanced, deep well, pumping unit has been continuously operating for eighteen years.

J. T. Ponder

R. L. Hoss

James Taylor Ponder has been elected as executive vice president of Kin-Ark Oil Company. Ponder, a member of the Secondary Recovery Association, is a veteran of the nation's oil and gas industries. Before the incorporation of Kin-Ark early this year, he served for seven years as general manager of Curtis A. Kinard's independent oil operatitons in Arkansas and Louisiana.

Robert L. Hoss recently was made production superintendent in the Rocky Mountain area for Vaughey and Vaughey, independent oil producers of Denver, Colorado. Hoss came to his new post from Midwest Oil Company at Denver where he was division manager.

He received his BS degree in petroleum engineering from the University of Tulsa in 1943. In 1947, following several years in service, he received his MS degree in petroleum engineering from the University of Texas, and joined Humble Oil & Refining Company. He left Humble in mid-1953 to join Midwest.

Earl A. Trager, formerly senior geologist for the Federal Power Commission, has been appointed chief geologist in the geological and valuation department of H. Zinder & Associates, Inc., Other affiliation in the sales department, announced at the same time, include the appointment of **Thomas L. Kister** as senior geologist, formerly exploration geologist for The Texas Company; **John Mullins** has been made senior petroleum engineer. Mullins was formerly reservoir engineer with the Union Sulphur & Oil Corporation.

Bob Sutton of Midland, Texas, has been appointed division landman for Cities Service Oil Company's Southwestern Division. **John W. Young** of Midland has been named to succeed Sutton as district landman at Midland.

Sutton was first employed by Cities Service in 1929 and has served as district landman out of Midland since 1941. He is moving to division headquarters at Fort Worth, Texas. Young has been a member of the company's Land-Geological Division since 1941. He was named landman at Midland in 1952. He is a member of the Permian Basin Landman's Association.

Lavon Gunter has been promoted to division land and leaseman, South Texas division of The Texas Company's producing department. He succeeds **E. H. Smith,** who retired in August. It also was announced that **J. B. Moore, Jr.,** and **John Kahanek, Jr.,** have been advanced to assistant division land and leasemen, South Texas division.

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Simultaneous Gamma Ray Neutron Log Cuts Rig Time

Only 3½ hours were required to log 4,742' with McCullough's simultaneous logging equipment. Gamma Ray and Neutron Curves and a collar log were obtained on the one run, logging the interval from 7,500' to 12,242' in a Mississippi oil well. 5½" O.D. 20 lb. casing had been set to bottom and hole was full of mud.

McCullough's simultaneous logging equipment is available in an increasing number of service areas. Ask your nearest McCullough Branch for details.

McCullough Radiation Well Log Picks Up Four Foot Pay Zone..... Glass Jets Perforate for 240 B/D

A fine example of the accuracy of the McCullough Radiation Well Logger in locating, defining and interpreting the nature of a thin productive zone so that it could be perforated for maximum production, has just been reported from a Kansas oil field.

This was a new well. 5½" O.D. 14 lb. casing had been set to bottom. McCullough ran a Radiation Well Log obtaining Gamma Ray and Neutron curves and recording a simultaneous collar log.

The log revealed a thin, four foot zone at 3856' and indicated that it was productive. The interval was shot from logging curves and collar log measurements with McCullough's 4" O.D. Super Casing Glass Jets in Steel Strip Carrier, four holes per foot. Total logging and perforating time was only three hours.

After perforating, the well had a good show of oil. Zone was treated with acid and made 240 barrels per day on test, which was a very good well for the field.

The McCullough Radiation Well Logger is the most accurate, reliable and efficient logging instrument available. It has greater stability, provides more detail and assures more accurate quantitative interpretation.

Because of the extreme efficiency of the scintillation counter in detecting radiation and because of its very short length, it is possible to log beds as thin as 12" with clarity and accuracy.

Whether the pay zone be thick or thin, the simultaneous recording of a collar log means placing the perforations exactly where they are wanted . . . fully covering the productive formation.

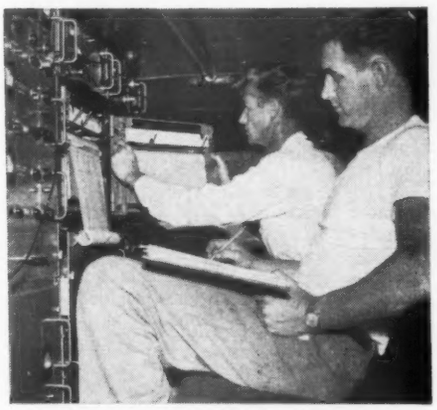
McCullough Log Finds Ten Feet of Pay Behind Casing

Sixteen Standard Casing Glass Jets Shot in 10' of Cased Off Pay Zone Increase Production from 5 B/D to 30 B/D

Many times the McCullough Radiation Well Logger has been instrumental in turning a poor producer into a profitable operation. While this Oklahoma well was a small producer even at its best, the 500% increase in production gained through the use of McCullough Logging and Perforating Services meant the difference between loss and profit.

The operator had set 4½" O.D. 9.5 lb. casing on top of the pay zone. The interval was treated but the resulting 5 barrels per day of production was considerably below the average for the field.

McCullough was called to run their Radiation Well Logger. Gamma Ray and Neutron curves were obtained along with a simultaneous collar log. It was found that 10' of pay zone lay behind the casing at approximately 1645'.



Interior of McCullough Radiation Well Logging Truck showing electronic instrumentation, controls, recorder, etc. At this panel down-hole information is evaluated and recorded with extreme accuracy.

Sixteen shots were fired in the 10' interval by a McCullough Standard Casing Glass Jet Perforator with Steel Strip Carrier. The well is now making 30 barrels per day—a good well for the field. Total time on the job for both logging and perforating was one hour, twenty minutes.

As a result of the success of this job the operator is now logging and perforating all his wells in the area.

It always pays to call McCullough. You can be sure of exactly locating and defining potentially productive formations. You can be sure of deep, uniform penetration of the pay zone by the "world's hardest shooting perforators."

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Copies of a technical article titled "Application of Radioactive Isotopes in Water Flood Operations" are available on request.

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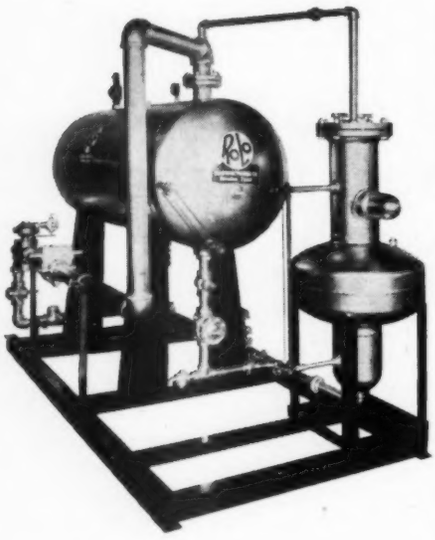

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Running Tour

▸ **Robert E. White,** Denver, has been promoted to assistant to the general management of Continental Oil Company's Rocky Mountain region. Formerly regional chief production clerk for Conoco, he will continue to make his headquarters at Denver.

Otis Cooney, San Antonio, has been promoted to assistant manager of Continental Oil Company's southern region production department. Formerly division production superintendent for Conoco at San Antonio, he will make his new headquarters in Houston.

Roy M. Mays, Denver, has been promoted to manager of exploration for Continental Oil Company's Rocky Mountain region. Formerly regional land superintendent, he will continue to make his headquarters in Denver. It was announced at the same time that **Ben D. Donnell, Jr.,** Denver, has been promoted from assistant superintendent to superintendent of Conoco's Rocky Mountain region land department, succeeding Mays, and that **C. B. Smith, Jr.,** Denver, has been promoted to regional geophysicist. Formerly assistant regional geophysicist, Smith succeeds **C. K. Shepherd,** who recently was appointed exploration manager of Egyptian-American Oil Company, a subsidiary of Continental Oil Company, with headquarters in Cairo, Egypt.

Consolidation of Conoco's offices in Corpus Christi have brought about several promotions and shifts of personnel. Heading an enlarged exploration division staff will be **T. D. Craft,** division land superintendent, and **L. J. Ryman,** division geologist, both from San Antonio; and **Vincent D. Mackle,** division geophysicist.

The Texas-Gulf Coast production office at Corpus Christi will direct the operations of Conoco district offices at Alice, Houston and Rincon near Rio Grande City. **C. J. Stanberry,** McAllen, formerly a district superintendent, will be superintendent of the new Conoco production division at Corpus Christi. He will be assisted by **George E. Crosby,** division petroleum engineer; **J. N. Garritson,** superintendent of natural gasoline and gas operations; **Frank S. Conway,** division chief clerk; and **Milton Young,** petroleum engineer. The latter four men all held similar positions at San Antonio.

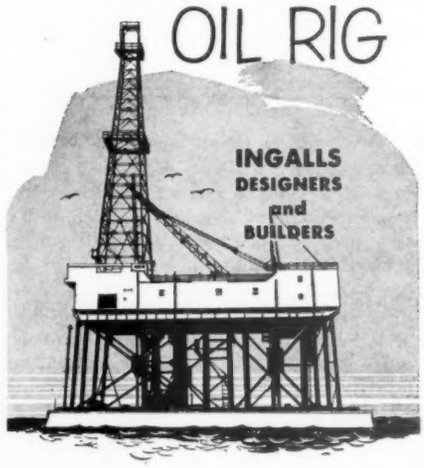
▸ **Stanley G. Bendorf,** formerly associated with Cities Service Gas Company and Phillips Petroleum Company, has resigned from the firm of DeGolyer and MacNaughton, of Dallas, Texas, on whose staff he was employed as a consultant in the preparation of geologic engineering and valuation reports of oil and gas properties. He was recently a witness in the Pacific Northwest Pipeline application that was certificated by the Federal Power Commission. Bendorf, as an independent petroleum consultant, has offices in the Fidelity Union Life Building, Dallas.

S. G. Bendorf

▸ **Charles D. Davidson** has resigned his position as assistant director of the geological engineering analysis section, Phillips Petroleum Company, Tulsa, Oklahoma, to join as a partner in the drilling and consulting firm of Wachtman and Schroeder, Pawhuska, Oklahoma.

▸ **James B. Gibbs** has been promoted to Kansas district production superintendent for Lion Oil Company at its Pratt, Kansas, production office. Gibbs joined Lion in 1952 and prior to his recent promotion was District Petroleum Engineer. Lion has also announced the transfer of **Fred A. Glassco,** district landman, from its Casper, Wyoming, office to Wichita, Kansas. He replaces **Kenneth Lane** as Wichita district landman in Lion's central region office.

Seagoing OIL RIG



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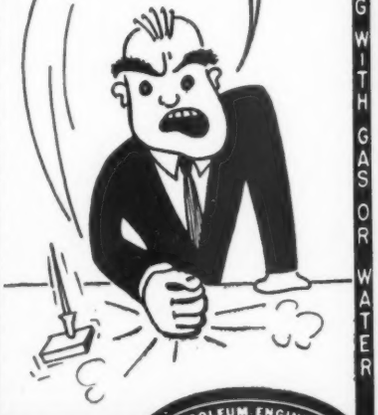

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DIGEST of NEWS and COMMENT ★ ★ ★

Refining . . . Petrochemical . . . Gas Processing

Lion-Monsanto Merger. Plunging Lion Oil Company, sparked and spurred by long-time board chairman Barton, ignition-power of that old independent firm, and trail-breaking Monsanto Chemical Company, are "marrying" to carry two phases of the country's most important non-food businesses, oil products and chemical products. Somebody offered somebody one and one-half shares of Monsanto's common stock for each share of Lion Oil stock held. Agreement has been reached, subject to stockholders' approval in a meeting soon to come off. Pertinent facts are that 40 per cent of Lion's annual sales, almost $100,000,000, is in chemicals; Lion owns two ammonia, fertilizer, etc., plants, the old one built just after World War II, and the other completed recently at Luling, Louisiana, not so far from New Orleans; the company has 24,000 bbl per day of crude production, and Lion has 1800 service station outlets.

Also Monsanto has better than $350,000,000 in chemical sales annually and facilities for making weed killers, insecticides, and desiccants. Lion has a good "tradin' hoss" in herbicides, extracted from petroleum of the Arkansas variety. Merged companies will own more than half a billion dollars of assets. Sounds good. T. M. Martin, Lion prexy, will head separate entity, Lion Oil Company division, Monsanto Chemical.

★ ★ ★

Cracker Cat of Kaolin. A new cracking catalyst is being distributed by Minerals & Chemical Corporation of America. It is made of kaolin, a special type of finely divided natural clay that is a hydrous aluminum silicate. The purified clay is made into pellets and is reported to be designed especially for use in the Houdry catalytic cracking process.

★ ★ ★

To Build Nuclear Research Center. A new and larger Van de Graaff accelerator is to be the "centerpiece" of the nuclear research center of Socony Mobil Oil Company at its Paulsboro, New Jersey, laboratories. Socony will participate with seven other companies to construct the first nuclear reactor to be built and operated by private industry for industrial and humanitarian research. Socony will build also "hot" laboratories for the manipulation of radioisotopes and for activities with materials such as Cobalt 60 and Iron 59 made radioactive by irradiation in the nuclear reactor; also a "counting" laboratory for assaying radioactive materials, office and medical facilities for the whole staff.

The first accelerator of this type was installed in Socony's Dallas, Texas, laboratories, but the new one will be larger, said W. M. Holaday, research director. Construction of these facilities will begin this Fall, and the whole is expected to be in operation within a year from that time.

★ ★ ★

Petrochemicals Plans Indefinite. Uncertainty shrouds the plans of Tide Water Associated Oil Company to get into the petrochemical industry. An ethylene unit for Avon, California, has been planned, but definite market outlets have not been forthcoming at the desired rate, so plans for that unit are said to be shelved but can be taken up again on short notice if conditions indictate that it might become feasible. According to reports, the plan for an ammonia unit has been scrapped as being a project not destined to prosper. Tide Water is building now on a large refinery on the East Coast (Delaware), said to involve $100,000,000 and more, and the possibility is that development of this plant's activities in the future may lead it into petrochemicals.

★ ★ ★

Olefins From Crude. Again the German "organischer Chemiker," unable to bring the mountain to them, have, Allah-wise, gone to the mountain. Light gases from refineries and natural gas have not met the needs for intermediates for solvents, plastics, and related materials. SO——

Two Farbwerke Hoechst researchers, Kamptner and Krekeler, have announced a method for producing olefins, those 'wild riders' of hydrocarbon chemistry, from vacuum distillation residues, crude-oil brown coal tars, and other waste-type heavy residues in Germany. High yields are obtained, claims say, and the process includes coke pellet formation, via moving-bed to coke pebbles into tubes at 1300 F. Heavy as well as light liquids can be formed at will by choosing operating conditions properly; liquid products for further thermal or catalytic cracking can be made also, but olefins are the main prospect as of now, reports say.

Phillips-Pacific Northwest Pipe Line to Make Ammonia. Apparently Washington state needs and plans to get fertilizers galore for its farms, orchards, and ranches. Phillips Pacific Chemical Company, subsidiary of multi-branched Phillips Petroleum, joins with Pacific Northwest Pipe Line Company to build a 200-ton-per-day ammonia plant in that state. The pipe line company will supply 15,000,000 cu ft of natural gas daily to supply hydrogen through the tremendous facilities of the Northwest. Atmosphere supply will be supplied per se. Gas will come from the fabulous San Juan Basin of northwestern New Mexico. Plant will be in operation late in 1956 and will supply ammonia and derivatives for the 1957 crop year in the Northwest. Phillips will design the plant, and Fish Engineering, Houston, Texas, will build it.

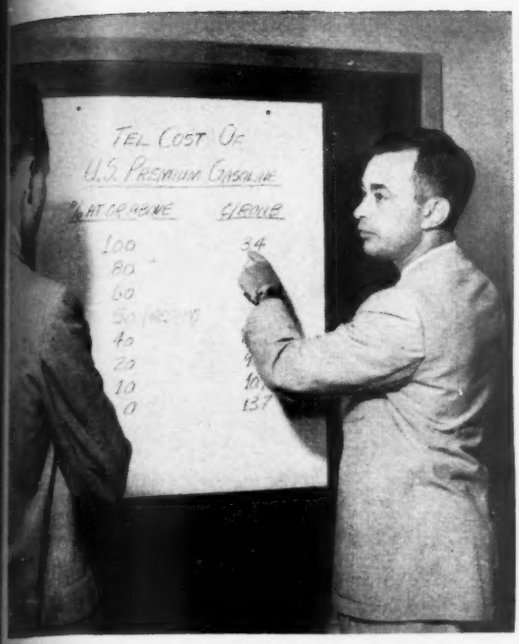
★ ★ ★

Engineering Students Work While Learning. Bridging the gap between the "cloistered halls" approach to scientific and engineering problems has always been a major quandary for both collegiate and industrial leaders. For some years now, four to be exact, one great engineering firm has done an outstanding job of introducing young engineers to practical problems of industry—by taking on several, nearly 20 this year, students and giving them a "course of sprouts" in the work, the demands, and the relationships in the organization and in the industry it serves. This is the Junior Institute of the M. W. Kellogg Company, held each summer. Object of the company is to try out job and man together, to give the students a peek at how things go in the workaday world, to get them acquainted with executives or "old heads" and taste the atmosphere of highly competitive operations, and to recruit likely young men for permanent employment in the company. The young men have regular jobs somewhere in the company's multichannel activities; visit plants, company research, and manufacturing facilities; sit down with top brass in engineering and executive positions, and attend a carefully planned series of lectures by leaders on pertinent technical problems, with the result that they go back to school with a fair-to-good understanding of the organization and the functioning of such a company and its work.

Seems like good recruiting.

Ethyl Refinery Technologist Wayne Warren explains the cost of various methods by which today's and tomorrow's gasolines can be made.

XUM



Incremental cost is the key to analyzing the economics of your top octanes. Here are typical cost figures for today's U.S. premium grades.

In each refinery the cost of top octanes depends on many variables...and that's another reason why Ethyl's experienced people can be helpful to you when you make your cost analysis.

Ethyl Research analyzes lowest-cost routes to top octanes

At today's octane levels, each small improvement in gasoline quality becomes increasingly expensive.

Can anything be done about it?

Ethyl Refinery Technologists have developed analysis techniques which may help define and thus minimize these costs. Key to analysis is the study of *incremental* costs . . . or the rates at which costs increase as you raise the octane number. (Handily expressed in cents per research octane number per barrel—¢/RONB.)

In your own refinery, an analysis of incremental costs may show that you can most profitably gain your top octanes by one of several processing alternatives. Or it may show that the cheapest route is to add lead up to the full 3 cc. Such a study can be very rewarding.

Our Refinery Technology staff is available to help you initiate and check your own analysis. Or if you prefer, we are equipped to do a complete economic analysis for you.

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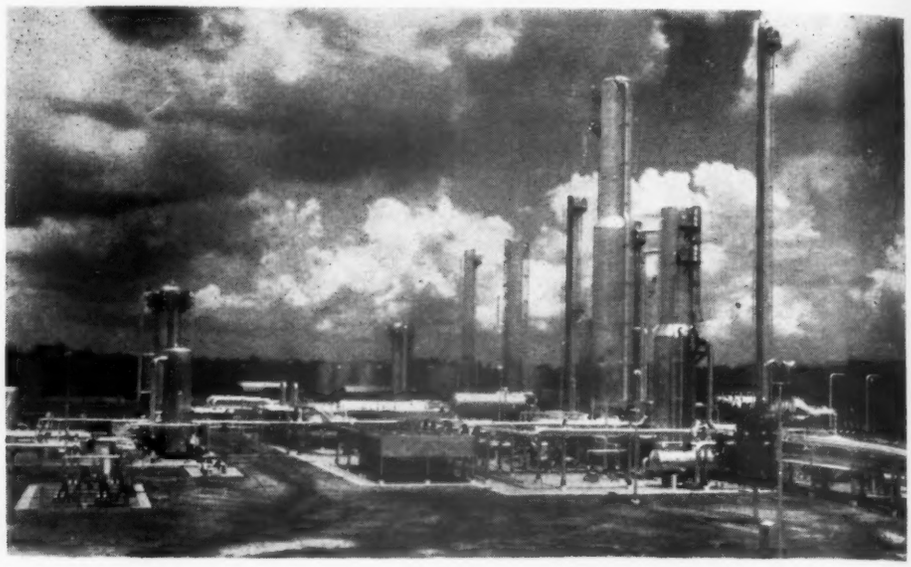
Selling Volatility in Motor Fuels Is a Major Project for the Industry



A typical absorption-fractionation unit for natural gasoline recovery; both steps are under intensive study to improve methods.

Natural Gasoline Has Four 'Bowstrings'

Arch L. Foster
Editor, Refining & Petrochemical Edition

THE natural gasoline industry, self-styled "Step-Child of the Oil Industry," now has more strings to its bow than it has had in its entire existence. Playing most of its life since the early 1920's from "behind the eight-ball," it now has an added impetus and importance that cannot be denied, and a situation that calls for more brains, backing, and brawn than it has found necessary to employ in its more than one-third century of life.

For the natural gasoline industry has been developing until it now has four "strings" to its industrial bow. These are: Natural gasoline itself, its main product, component of motor fuels; Liquefied Petroleum Gases, as motor and domestic heating fuels; LPG as petrochemical raw materials; sulfur recovery, and the making of special solvents, fractions, etc.

Even in its major product, the natural gasoline industry is entering a new era of endeavor and is facing a new challenge to its ingenuity, has a new principle to "sell." That principle is use of natural gasoline, synonymous with volatility, for its effect on fuel performance aside from any specific octane rating evaluation of natural. Recent years have seen the unearthing of much important information regarding the relationship between volatility per se, and the anti-knock requirement of motor fuel. Not nearly all the possible practicable advantage is being taken now of the inherent value of volatility in motor fuels.

Truth is, the natural gasoline industry has two big-caliber jobs in developing its present and future outlets for natural gasoline. The one is to sell the important effect of volatility on the octane requirements, and the general performance of motor fuels. The other is to sell the automotive engine-fuel system designer on the high desirability of so designing these systems that a much greater percentage of 'volatility' can be included in these fuels safely from an operational viewpoint.

EXCLUSIVE

Corollary to this last item is that of selling the state and federal governments on the principle of relaxing vapor pressure specifications to permit the marketing of considerably higher vapor pressures.

It has been determined, on the basis of the additional amounts of butane that could be added to current motor fuels in summer, that a total of more than 4,000,000 bbl of butane per month can be included in motor fuel and sold at motor fuel prices rather than at LPG prices during about six months of the year. This butane is not included now in motor gasolines. With a total of about 25,000,000 bbl (1,050,000,000 gal), per year more butane going into motor fuel, butane that now must be sold elsewhere, the picture for natural gasoline assumes an entirely different prospect. And some of the best qualified authorities believe (Legatski and Elder, NGAA, 1954) that the actual possibilities for butane blending is 50 per cent or more higher than the 25,000,000 bbl figure.

The impetus to induce the refiner and the motor fuel user to use more butane is the effect of added volatility on actual octane number requirements, on warm-up, better cold and also hot weather starting. Similarly, it has been found that by bringing volatility up so that the 90 per cent evaporated temperature is lowered from 350 F to 300 F will lower the octane requirement from one number to four octane numbers in the same engines and with all other conditions the same. Since deposits affect octane needs seriously, it has also been found that in using a more than conventional volatile fuel, the difference between the octane requirements for the same engine, using at one time a multi-viscosity SAE 10W-30 crankcase lubricating oil and in the other a conventional HD SAE 30 oil, is three full octane numbers. Also the light oil had nearly 3½ times the mileage on it that the HD oil had. As result of these extensive tests, Tongberg and associates (SAE meeting, January, 1955) conclude that "It will be entirely feasible to operate 9.5 to 1 and 10 to 1 compression-ratio cars on 98-99 Research Octane number fuels *of the proper volatility* using a multi-viscosity lubricant." Also, comprehensive data indicate that as more volatile fuels and multi-viscosity lubricant become more widely distributed and used, compression ratios of engines can be raised without increasing octane ratings of these fuels.

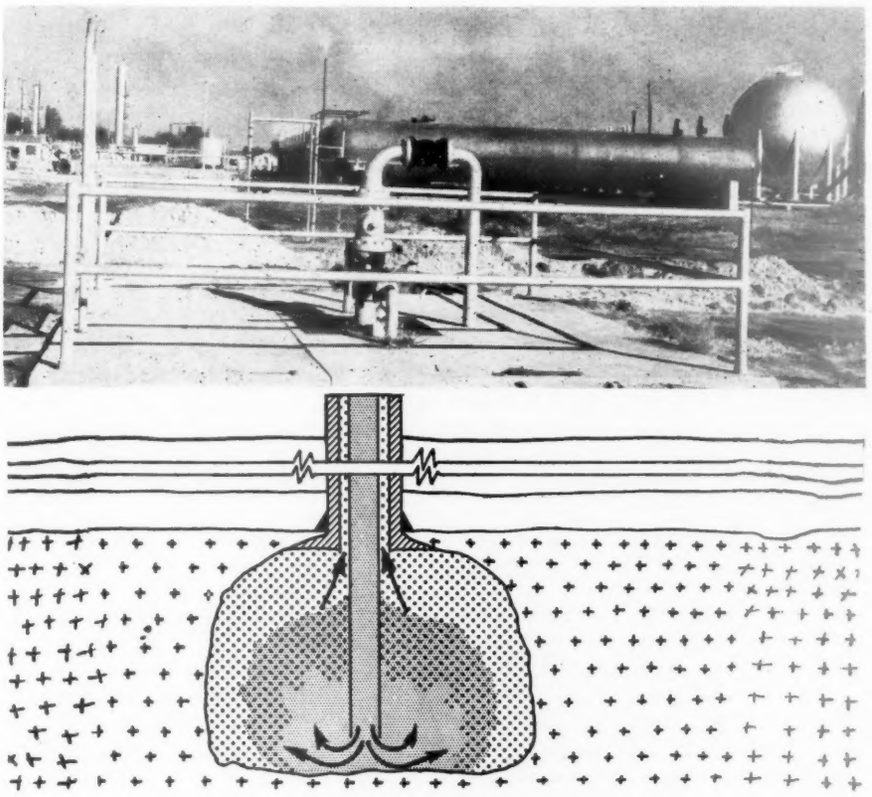
These considerations just mentioned are the main facts that should sell the refining industry and the car operators on the use of more volatility in fuels. It increases the amount of gasoline that can be made from each barrel of crude, it eases the pressure on processes producing octane numbers and thus makes for cheaper fuel, and it gives better performance with existing octane-number fuels. Since butane is cheaper than refinery gasoline components, the fuel refiner-blender can pass some of the increased price of butane-in-gasoline on to the natural gasoline manufacturer, can sell gasoline for a lower price to the consumer, and can improve his own financial balance also. Estimates say the industry can save for itself, the motorists, and the automotive industry $100,000,000 annually by adding more butane.

Fuel Systems, Specifications To Change?

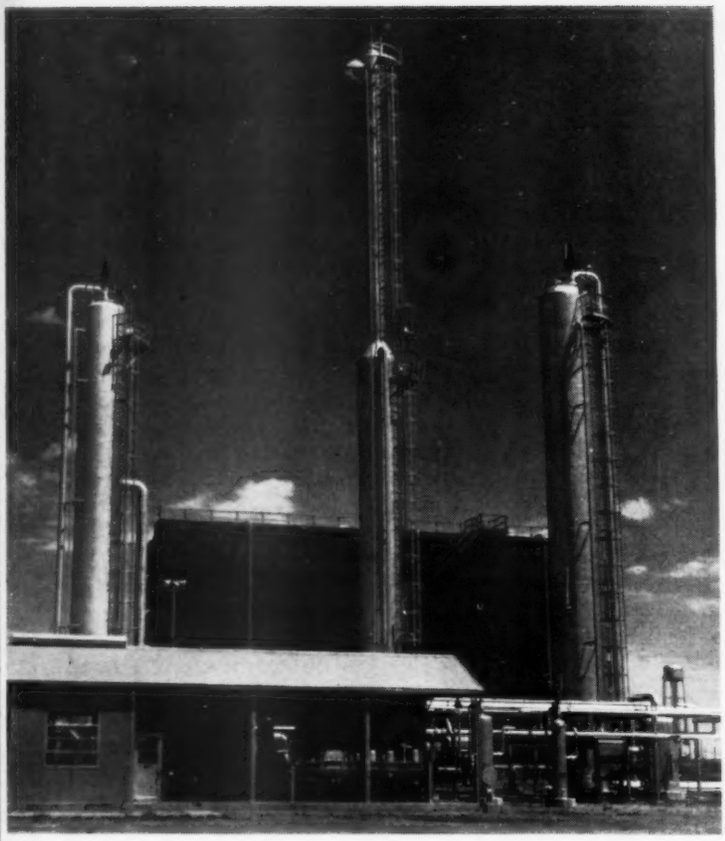
The problem of blending more butane in motor gasoline is no problem. But the problem then really begins. The fuel systems of current cars, while better than those on prewar cars, still do not permit the vapor pressures to be raised very much without incurring vapor lock. Last year it was determined that at 85 F air temperature postwar cars can use 10.3 Reid vapor pressure fuels satisfactorily, whereas, prewar fuel systems could handle no higher than 8 RVP fuels. At the same time, the investigators found (Barnum, Clarke, Hamer, SAE, June, 1954) that the average summer vapor pressure of U. S. motor fuels was 9.1. This gives a margin of 1.2 RVP above current commercial average that will still satisfy 100 per cent of postwar cars. In other words, the refiners are not generally including all the volatility they can add safely, and they could utililize a great deal more butane, in the form of higher vapor pressure natural, than they are doing now.

Furthermore, a "team" of researchers in the summer of 1954 found by testing more than 100 cars on the East and West Coasts that the Reid vapor pressure method is no longer adequate or a satisfactory test for vapor pressure. Tests under widely varying conditions showed no essential correlation between Reid values and vapor locking tendencies. Some fuels of lower RVP values showed more vapor locking trouble than did other fuels with higher numerical Reid ratings. In the cases of some car models that showed exceptionally high tendencies to vapor lock, their problem can be solved only by redesign of fuel systems to protect carburetor, fuel lines, fuel pumps, etc. from excessive engine heat. These investigators (Heath-Thens, SAE, January, 1955) stated that the fuel distillation temperatures could be combined with vapor pressures in some manner to show more accurately and satisfactorily the comparative vapor-locking tendencies of fuels.

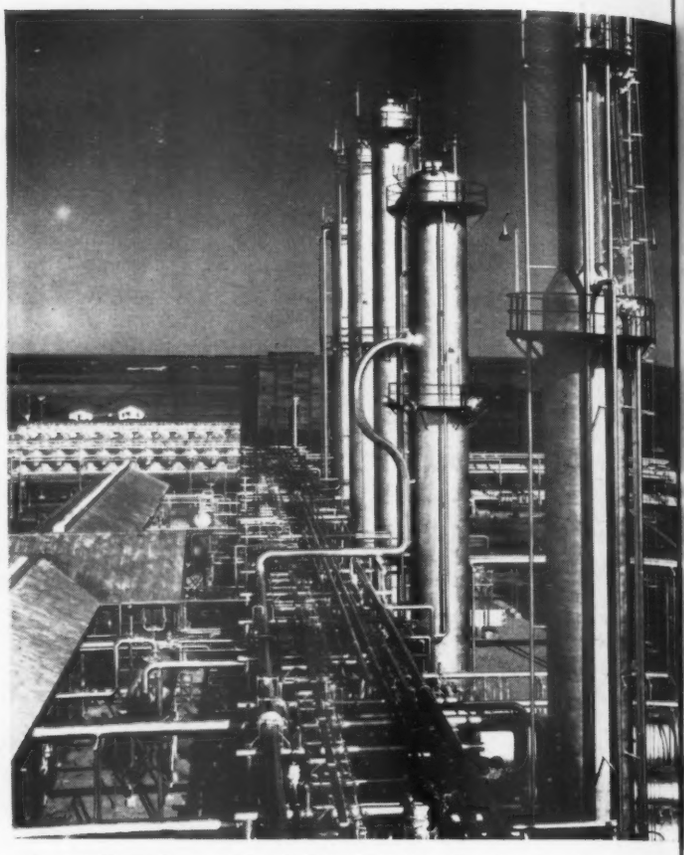
The second hurdle to be overcome by the industry is to induce the motor car fuel system designers to build these systems to avoid excessive heat on the fuel as it traverses the route from fuel tank to intake manifold. In this item, as in many others, the entire picture of under-hood installations must be considered. The ideal fuel system would be entirely outside the hood in the coolest spot around the forward end of the car, operating at the lowest atmospheric temperature around the car. Not only do mechanical limitations throw out this suggestion, but matters of appearance and compactness militate against the idea. Shields have been employed between fuel system and engine, but with not too signal success. A general principle is that the fuel lines from rear tank to fuel pump



(Above): All that shows of an underground LP-gas storage cavity is the pipes, valve, and fittings. (Below): Theoretical salt cavity below the above-ground piping may look much like this.



In this absorber-fractionator combination, the smaller diameter column above is a deethanizer, atop the larger column, which is the absorber.



A complicated assembly of absorbers, fractionators, exchangers, and pressure storage tankage mark the modern natural gasoline plant's design.

should pass on the outside of the frame channel iron, or its equivalent, protected from the engine heat drifting backward between the frame sides. Of course, positive displacement, or "pusher" type pumps will eliminate the entire problem, forcing vaporized fuel out of the system into the carburetor and manifold as fast as it is formed; however, this may introduce mechanical troubles in the driving of the pump, or it may not. Most car makers still use the old suction pump.

Third, and by no means least, is that of ASTM, federal, and in many cases state specifications for legal fuels, which must be relaxed to permit sale of fuels of higher vapor pressure; also, of course, it is necessary either to revise the test methods or to perfect new methods that will allow the marketing of higher volatility fuels. These matters once fixed in laws or in the standard test methods are very difficult to get changed and require long and arduous work to decide on new standard procedures and legal limits. It will be necessary for the industry, both manufacturers and consumers of petroleum products, to work together to remove or alleviate these artificially imposed restrictions to progress and these hindrances to taking advantage of newfound knowledge of fuel and fuel-system behavior. Especially must attention be given to Committee D-2 of the ASTM and to the Society of Automotive Engineers regarding changes in specifications and test methods to take advantage of developments made in recent years. Motor car manufacturers must see their way clear to improve fuel systems—they have been told and retold, over and over, scores of times in the last 10 years — to the common advantage, and especially for the ultimate consumer, the customer, to have cars that handle cheaper and better fuel that can be made in greater quantity at lower cost and improved power performance to enable the industry to make great quantities of fuels from the available raw materials, crude and natural gas, to meet the rapidly rising demand of the whole public for more and more fuel. Increase in fuel demand is 5 to 8 per cent annually over the preceding year. Use of more butane will relieve in good measure the pressure on the industry to produce gasoline in sufficient quantity from available crude, reduce the strenuousness of efforts to find more crude production at a greater discovery rate.

LPG a 'Lusty Infant'

Liquefied Petroleum Gas, propane, butane and mixture thereof, sold in 1954 in the quantity of 5,000,000,000 gallons. (Benz-Tucker-DeVoe, PE, January, 1955, p. C-27). While its use for synthetic rubber and for gas manufacturing dropped somewhat, the entire bill was 4.1 per cent above 1953. For domestic and motor fuel use, the amount is estimated at 3,250,000,000 gal, up 9.2 per cent over 1953.

It is rather axiomatic that every home, every business building, etc., out of reach of natural or manufactured gas lines is a potential customer for LPG for heating in winter, for cooking at all times, and thus a potential customer for the equipment necessary to set up an LPG fuel system in that home or building. The only competitors LPG has are wood in some areas, coal, or kerosine (distillate fuel oil included). And for cooking, LPG easily has the nod over any of these, where available.

Therefore, this whole picture, or problem, is a matter of selling. Estimates are made of more than 625,000,000 gal of LPG for motor fuel use last year. Twenty-five hundred buses use it as regular engine fuel; more than 200,000 tractors and other farm equipment use it, and the number of irrigation engines, taxicabs, and trucks employing LPG is tremendous, though the exact figures are not known. In this

case too, every truck, tractor, pumping engine; every bulldozer, dirt mover, and any other ignition-engine powered unit of every sort is a potential or actual user of LPG. Necessarily, the refiners will fight to retain their gasoline, distillate, and diesel-fuel consumer markets, and the matter of selling LPG must be done on the merits of the fuel and its advantages, which latter can be demonstrated, under present conditions of supply and price structure.

Shipments of LP gas cooking ranges last year to dealers and/or customers was more than 400,000; LP gas water heaters 275,000; slightly less than the 1953 number; but space heaters (furnaces) were sold in numbers more than 390,000, nearly 30 per cent of the total sales of all types of gas-fired furnaces. The tremendous number of potential customers for all these appliances and for LP gas or other fuels for them gives the "go-ahead" signal to any efforts looking toward increasing all these sales.

On the production-supply side of the picture, the phenomenal increase in the use of underground storage for LP gas bids fair eventually to solve partially or wholly one of the industry's big headaches, that of taking care of LP gas during off periods of production in order to have it on hand when peak sales periods are on us. On January 1, 1954, the country had underground "cavern" storage for but 246,000,000 gal; on January 1, 1955, this figure had climbed to 458,000,000 gal, with 250,000,000 gal under construction. This gives for the end of 1955 a prospective figure of more than 700,000,000 gal of storage in use, and with the as yet unknown capacity to be built or begun in 1955, it is probable that 1956 may see the total storage capacity approach the billion gal mark. Instances are known where six, seven, or more caverns have been developed, usually by leaching salt from a salt dome or stratum, in a single area.

Petrochemicals, Specialties To Expand Indefinitely

The potential for the manufacture of petrochemicals from LP gas, either natural gas or refinery derived, is an indefinite quantity but will increase probably without a backward step for a long period of years, in fact, we cannot say it ever will recede, likely. Uses of this raw material for synthetic rubber components in 1954 dropped to 317,000,000 gal, down nearly 19 per cent from 1953. Petrochemicals consumed 977,000,000 gal as compared to 967,000,000 gal the previous year, a growth of one per cent. It is reasonably certain that the trend in propane-butane consumption in these fields will be determined by the ability of the rubber and chemical makers to find outlets for their products. Installation of additional capacity for the use of these raw materials is a simple matter if the possible or actual market for the finished products or intermediates made from them exists as actuality or likely probability. The big selling job in this phase of the industry is on the neck of the chemical and rubber manufacturers, not the natural gasoline industry, and the situation at any time will be governed by conditions outside the natural gasoline industry. The same will be true of specialities including sulfur. Recovery of sulfur will be determined by market demand, by concentrations of sulfur-bearing gas at or in easy reach of any given point, and, of course, in general by the cost of recovery. More details on the petrochemical prospect are given in the article by Crockett in this issue.

Technical Research Progressing

Among the several investigations being carried out cooperatively and individually in addition to underground storage, may be mentioned the coalition of facilities, manpower, and finances known as Fractionation, Inc., a non-profit research project financed by some 40-odd refining and natural gasoline companies to study the practical fundamentals of separation of hydrocarbons by fractionation. This project has been undertaken to study intensively the various pieces of equipment, mainly fractionating trays developed and employed currently, and to work out ways and means to improve to the greatest degree possible the best new methods for fractionating and separating hydrocarbons. Powered by an outstanding staff of engineers, physicists, and scientists, the scientific data developed will aid materially in perfecting fractionation practices in refining, natural gasoline, and petrochemicals. In fact, they will be a tremendous potential advantage to the entire petroleum, gas and chemical industries, all industries that employ fractionation as part of their operating techniques. A report on the work of this research organization is presented elsewhere in this issue.

Equipmentwise, the industry has numerous new and/or improved methods and apparatus to aid its operations; analytically, the new Thermocon system for low temperature analysis (Refining & Petrochemical Edition, May, 1955, p. C-17) marks a new achievement in that field. The Fracton system for light hydrocarbon analysis (elsewhere in this issue) is used widely. Electronic-control systems are coming to the fore; radioactive tracer elements are being adapted more and more to measure and indicate with exactness important facts that heretofore had to be estimated or "guestimated." Numerous other innovations, large and small, could be mentioned if space permitted.

Prosperity a Sales Job

An obvious fact is that the products of the natural gasoline industry fall into two categories. Some of them, like natural gasoline itself and light materials like LP gas for petrochemicals, are controlled largely by demand that cannot be expanded by sales effort alone. Their consumption is determined by market demand for motor fuels or for petrochemical finished product. Sales pressure on these products must come indirectly, by boosting the consumption of the finished products.

Other materials, such as butane, propane, etc., lend themselves to market expansion by more direct sales effort. Use of more butane for motor fuels is contingent upon: (1) Improved design of automotive fuel systems; (2) taking advantage of the highest volatility that present systems can handle in any given locality; (3) relaxing federal and state specifications for vapor pressure, and (4) devising a new and better system for designating and evaluating vapor pressure, or volatility. In all these, a sales job exists that must be done properly to achieve the best results for all concerned.

The four "bowstrings" that the natural gasoline industry now has may be designated:

1. Natural gasoline itself, main product and mainstay of the industry, for motor fuel blending.
2. LP gas for motor fuel, and for primary gaseous (domestic, etc.) fuel.
3. Light hydrocarbons especially propane, butane (LP gas) for petrochemical raw materials.
4. Specialties, such as sulfur, solvents, thinners, individual hydrocarbons, hydrogen, and carbon monoxide (synthesis gas).

Expansion of the outlets for No. 2, 3, and 4 will depend more on sales effort to increase the use of these products by the public and by other industries. Increased use of natural gasoline itself depends on several considerations, especially developments for use of increased volatility in motor fuels, convincing the refining industry of the advantages of volatility as affecting performance of fuels as either reducing the octane requirements or giving greater performance with any given octane rating. * * *

Fractionation Research

The article presented here has been prepared to bring the technical men and executives of the industry up-to-date on the progress and developments made to date by this organization, formed and supported on a non-profit basis to further the most ambitious research program yet undertaken by the industry's refining, natural gasoline, and petrochemical interests. Composed of 43 companies and staffed by employees of many of these companies, the group is under the technical leadership of the author, Francis W. Winn. The results of this research in large-scale pilot-plant equipment, are expected to give greater impetus to improved design than any work that has ever been undertaken by the industry.

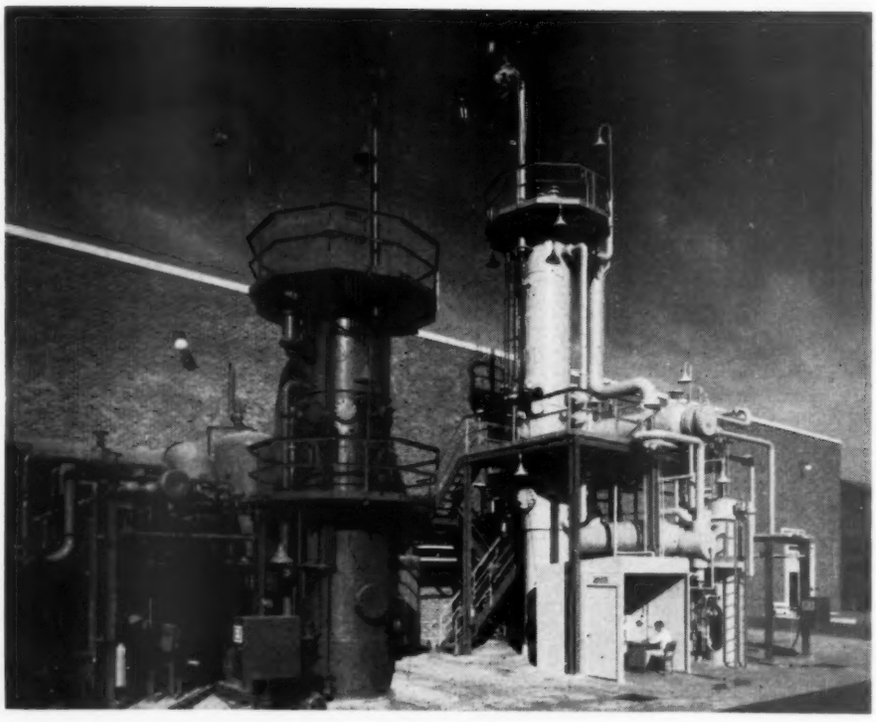
This article should be read by everyone interested in any manner in the technical progress of the oil, gas, and petrochemical industries.

—EDITOR.

Developments in Fractionator Design

A broad, cooperative research program is discovering fundamental principles in fractionator design

Francis W. Winn
Technical Director, Fractionation Research, Inc.



A view of the two pilot-plant scale fractionator columns being used to study fractionator design.

THE search for better information on capacity and efficiency of both old and new types of fractionation columns continues at an accelerating pace. Many articles related to design and operation of fractionation columns have been published. The various design methods, however, frequently differ appreciably. Unfortunately, very limited data are available by which one may choose the most appropriate method even for ordinary design problems, and the situation is even more challenging for out of the ordinary problems.

Bubble-cap trays are used more extensively than any other type of vapor-liquid contacting device. The general rule in the past was to design such trays with considerable excess capacity to allow for contingencies of inadequate design information. As a result, many of the earlier towers could be operated greatly in excess of "design" capacity. Others, due to sometimes obscure limitations, have not met design capacity. The tendency to compare new fractionating devices with bubble-cap trays may be misleading if the chosen bubble-

cap tray is not of the proper design. Some of the limitations that plagued bubble-cap trays built in the past have been recognized, and the more recent designs have considerably higher capacities. An article by Young[24] describes how it was possible to increase allowable velocities by 60 per cent and reduce the number of trays by 20 per cent for a typical bubble-cap tower. This was made possible through research in fractionation, resulting in more reliable design information.

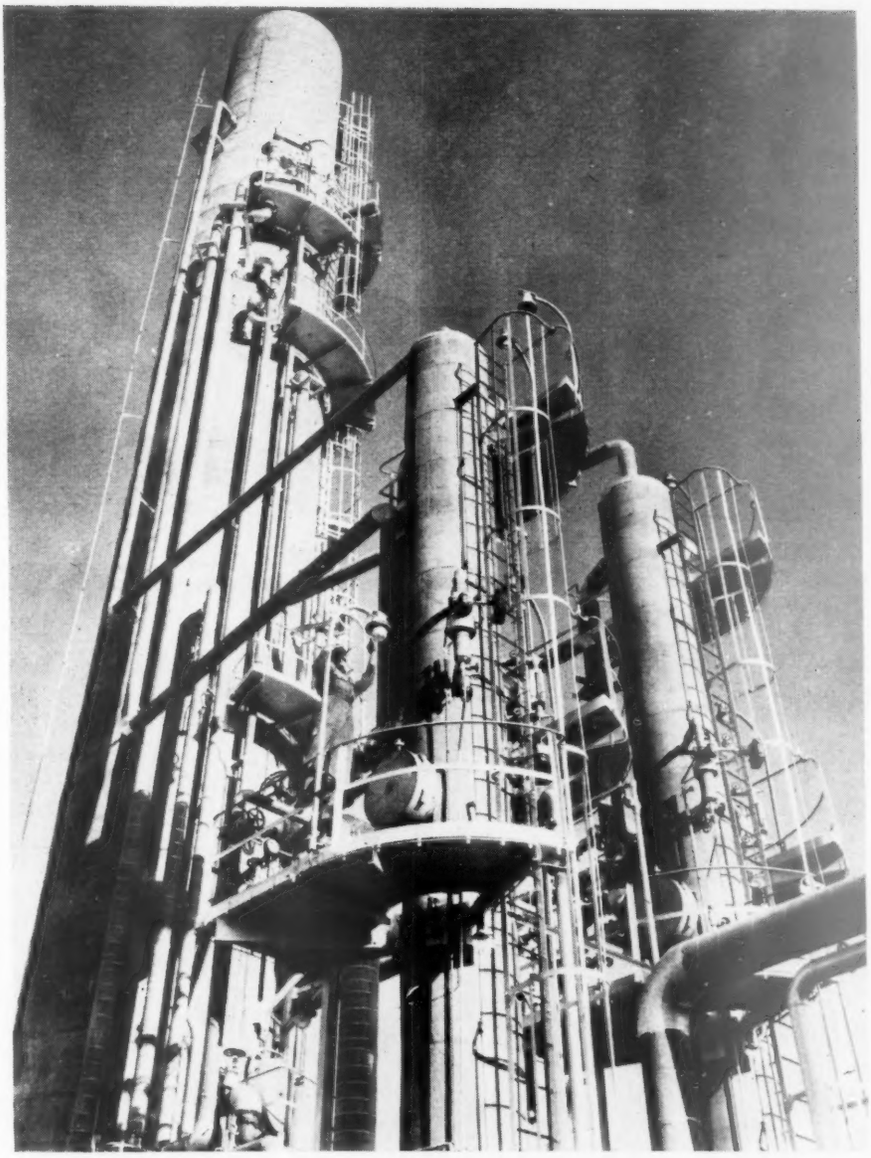
As a result of the uncertainty in fractionator design, two research groups and a number of individual companies are active in the quest for more reliable knowledge of vapor-liquid contacting devices. One of these groups is Fractionation Research, Inc., a non-profit company, which was organized for the purpose of determining and comparing the efficiency and capacity of all types of fractionating devices. FRI's research program is being conducted with large-size columns, a 66-in. three-tray simulator leased from C. F. Braun & Company and a 48-in. ten-tray distillation unit owned by FRI. A photograph of these two columns is shown.

The simulator is used for studies of pressure drop, flooding, hydraulic gradient, and entrainment utilizing such systems as absorption oil, hexane or water with nitrogen, natural gas, or carbon dioxide. The distillation unit is employed for evaluation of tray efficiency, entrainment, pressure drop, and capacity with systems such as n-heptane and cyclohexane, n-butane and isobutane, and isopropyl alcohol and water. Additional binary and multi-component systems will be studied in the future.

A bubble-cap tray tested in the FRI distillation unit had a flooding capacity of as much as 170 per cent of the "allowable" computed by the methods of Souders and Brown,[20] Robinson and Gilliland,[18] or the Chemical Engineer Handbook.[5] Tray efficiency for the butane system was as high as 120 per cent and was relatively independent of vapor velocity up to 98 per cent of the flooding load. Efficiency was found to vary appreciably with composition and pressure. These effects, together with the effect of entrainment, have been correlated by use of a relatively simple equation.

Fractionation Research plans to do extensive field testing of large-diameter fractionating columns in order to extend the results from the 48-in. column. These efforts are being guided toward reliable methods for designing and predicting the performance characteristics of all types of fractionating columns.

The second group effort is by the research committee of the American Institute of Chemical Engineers, which is sponsoring research on bubble-plate columns at three universities. The aim of the work is to study the effect of system properties and tray design on efficiency. The effect of tray-design variables is being studied in a 24-in. diameter high-pressure column. System properties are under study in two 8-in. square atmospheric-pressure columns. The work is pointed toward testing the reliability of computing tray efficiency by adding individual gas and liquid film resistances. Initial results from the small-diameter column studies indicate that this approach may be used to predict the efficiency of large-diameter columns.

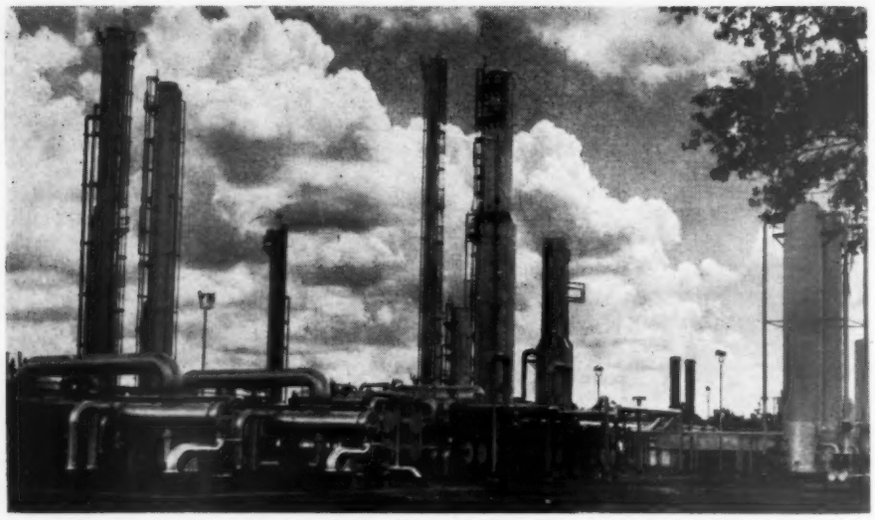


These fractionators in a large new refinery "down under" (Kwinana, Australia) separate all-important light fractions in making commercial products.

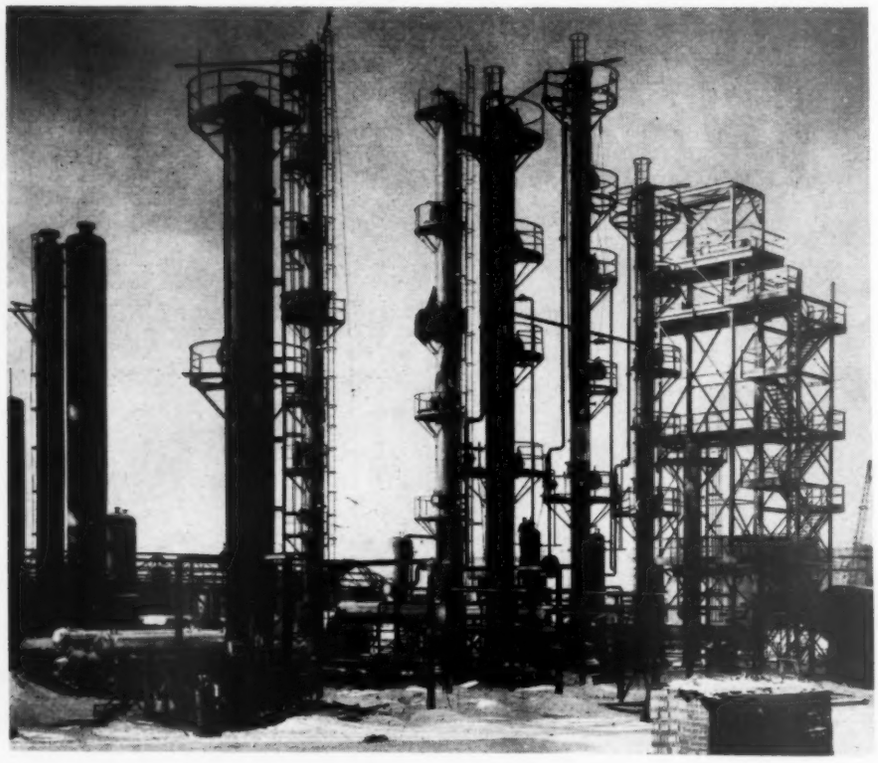
Proprietary Devices

The long-standing dominance of bubble-cap trays is continually being challenged by new properietary devices. Several new-type trays available for licensing were publicized during 1954-55. Additional performance data on earlier proprietary devices were also published.

A new design in bubble-cap trays called Uniflux is described by Bowles.[3, 4] This tray consists of a number of lazy-S members attached to the tray support ring, with the slotted edge of one member lying in the through section of the adjacent member. Vapors issue forth in a direction parallel to liquid flow, boosting it across the tray and compensating for hydraulic gradient. The trays have been installed in more than 100 towers with no troubles having been experienced. The performance is stated to be at least equivalent to a well designed bubble-cap tray, and the cost is said to be only 60



Units installed in this Gulf Coast natural gasoline plant (Pledger) are the last word in fractionators.



A refinery vapor-recovery unit is the counterpart of a gasoline plant, and employs fractionation primarily.

per cent of a conventional bubble-cap tray.

Two "valve-type" trays with moving parts are now available. The Float-Valve was first introduced in 1951 by the Nutter Engineering Company. Performance data on this tray were published recently by Nutter.[16] The second valve-type tray, the Flexitray, was introduced in 1954 by Koch Engineering Company. Advantages claimed for this tray are its low cost and wide operating range at moderate liquid loads.[12, 22]

The recycling tray described by Ragatz[17] is a perforated tray with "recycling," box-like baffles attached to the tray floor perpendicular to liquid flow. Increased capacity and efficiency are claimed for the tray.

A novel switch in gas-liquid contacting making use of perforated trays is described by Nord.[15] This tray features concurrent contacting of gas and liquid through perforated trays. An overall countercurrent movement of gas and liquid is obtained between stages by the use of gas upcomers and liquid downcomers. Advantages claimed are low pressure drop, elimination of entrainment problems, and intimate contacting at low gas or liquid rates.

Column Performance

A number of informative articles was published on column operation and testing during 1954-55.

May and Frank[13] describe how several 10-ft vacuum fractionators in ethylbenzene-styrene service were limited in capacity by a cyclic upset due to hydraulic gradient aggravated by vapor cross-flow. The liquid load was low, less than one gallon per minute per inch of weir length, but there were 23 rows of caps normal to liquid flow. The calculated hydraulic gradient was only 0.67 in. of liquid, but the visual estimate of the gradient was 1 in. Several rows of inactive caps on the inlet side of the tray and a strong, horizontal vapor cross-flow of a cyclic nature were observed through windows. New columns of identical design but having staged slot height had a capacity of 150 per cent of the earlier designs. This article brings out the importance of hydraulic gradient considerations for large-diameter towers in vacuum service.

Gagneux and Hiser[7] describe how the operation of an underloaded stripper and associated absorber was improved appreciably by increasing vapor velocity in the stripper. Reduction of feed preheat or blanking caps resulted in a more stable plate and a greatly increased recovery of desired components.

The effect of number of trays on efficiency from absorber tests is described by Kennedy, et al.[9] Although tray efficiency is not a function of number of trays, per se, the test results indicate overall tray efficiencies for butane of 24 and 15.5 per cent for 20 and 40 trays, respectively. The calculated incremental efficiency going from 20 to 40 trays is only 7 per cent. The authors recognize that relatively small errors in analyses could have very pronounced effects on calculated tray efficiencies. Equilibrium data and the method of calculating the number of theoretical trays also may have affected the results. Assuming the analyses and theoretical tray-number calculations were correct, efficiency in the bottom few trays of absorbers, where temperatures and concentrations of the heavy key and heavier components are high, may be much greater, however, than in the top section, where opposite conditions exist. The test results also showed a considerable reduction in the absorption of methane in the tower having 40 trays over that having 20 trays.

A comparison of the capacity and efficiency of perforated plates with

bubble-cap trays is reported by Kelley.[11] The perforated trays were installed as a replacement for corroded, cast iron bubble-caps in a 6-ft diameter absorber. The capacity of the perforated plates was considerably higher than the bubble-cap trays that were replaced. The replaced bubble-cap trays may have been limited, however, by restricted downcomer pipe-seal cups. The perforated trays had a lower capacity than another bubble-cap absorber having adequate downcomer area, but calculations showed it would have had a comparable capacity if blanking strips that covered a portion of the perforated area had been removed. It was anticipated that the perforated plates would show a higher efficiency than the bubble-cap trays because of a longer length of liquid travel. No difference in efficiency, however, could be detected. This was explained on the basis of Gautreaux and O'Connell's equation[8] showing length of liquid travel to have little effect when point efficiencies are low.

The effect of load and pressure on the performance of a 50-tray, 3-ft diameter butane splitter is described by Clay, et al.[6] Test results indicate the flooding capacity of this column was independent of liquid rate. Tray efficiency was found to be a minimum at intermediate concentrations. Overall efficiency was relatively independent of vapor load up to 90 per cent of flooding. Examples are given to show how the optimum pressure for a given feed composition may change with the desired separation.

How to test fractionators is the subject of two articles by Kelley, et al.[10,10a] In the first article, a description of test procedures and various means for detecting flooding are given, and the importance of determining the tray where flooding starts is stressed in order to locate possible restrictions. The second article describes actual test results on a Fluid Catalytic Cracking Unit primary fractionator and shows the application of published methods for calculating pressure drop and vapor and liquid handling areas required for higher capacity. Increasing the downcomer area and changing cap design to reduce reversal and annular area restrictions made it possible to increase the vapor load in the tower by the predicted amount of 16 per cent.

Design Methods

Design methods were a popular subject in the literature recently. Some articles were comprehensive and others pertained to specific aspects.

A new approach to the design of bubble trays is described by Atkins.[2] The required cap field, liquid handling, and "edge-loss" areas are calculated separately. These areas are functions of the vapor and liquid rates, density, service, and tray spacing. The sum of the three areas is the required tower cross-sectional area at a load of about 75 per cent of flooding. The method is claimed to result in a tray design that is properly proportioned for the required liquid and vapor loads so as to be stable and not have an excessive hydraulic gradient. This article also gives methods for calculating pressure drop, entrainment, and tray efficiency. The efficiency equation does not take system properties into account and for this reason, it is doubtful that it would be applicable to all systems.

Another approach to tray design is given by Munk.[14] This article gives a procedure for determining the operating limits of various cap designs and tray layouts using published methods for calculating pressure drop, allowable vapor rates, entrainment, etc. Charts are given to illustrate the operating limits of several tray designs.

A quick method for sizing refinery distillation equipment is given in an article by Atkins and Wilson.[1] A plot of tower capacity, expressed as barrels per day per square foot of column cross-sectional area, is given as a function of service and tower pressure. Short-cut methods for calculating the number of trays and heat-transfer surface are also given.

Sieve-tray design and operating experience are discussed in an article by Lee.[12] The use of tilted plates, recessed-inlet seal pans, and no perforations closer than 2 to 4 in. from the inlet weir reduce weeping to a minimum. Operating experience of the Celanese Corporation indicates perforated plates have a flat efficiency curve that is from 5 to 15 per cent higher than bubble-cap columns. The operating range is wide, and both initial cost and maintenance expenses are less for perforated trays than bubble-cap trays.

Simkin, et al,[19] shows an empirical correlation of entrainment from bubble-cap trays as a function of tray spacing, seal depth, vapor velocity, and density of the vapor and liquid. The correlation shows good agreement with experimental data for columns of 15 to 36-in. diameter. It is pointed out that the effect of liquid cross-flow probably is a significant factor in larger-diameter columns and that the correlation is somewhat uncertain for application to such columns.

Gautreaux and O'Connell[8] present the derivation of an equation relating local efficiency to Murphree-plate efficiency using the hypothetical concept of pools or stages of liquid to account for liquid-concentration gradient across a tray. This approach gives weight to the effect on efficiency of liquid-path length. A plot of local efficiency (speculative) as a function of the relative volatility times viscosity and another plot showing the number of stages versus length of liquid path are given. The two plots used in conjunction with an equation permit an estimate of Murphree-plate efficiency.

A correlation of slot opening of bubble caps for triangular, rectangular, and trapezoidal slots is given in an article by Winn and Keller.[23] The correlation shows an average deviation of 0.05 in. when compared to literature data.

The Author

Francis W. Winn was graduated from the University of Oklahoma, after which he began his professional career as a chemical engineer with Pan American Petroleum Corporation. Following an assignment with the Petroleum Administration for War, he was employed by the Socony-Vacuum Oil Company and Catalytic Construction Company. Winn is now technical director of Fractionation Research, Inc.

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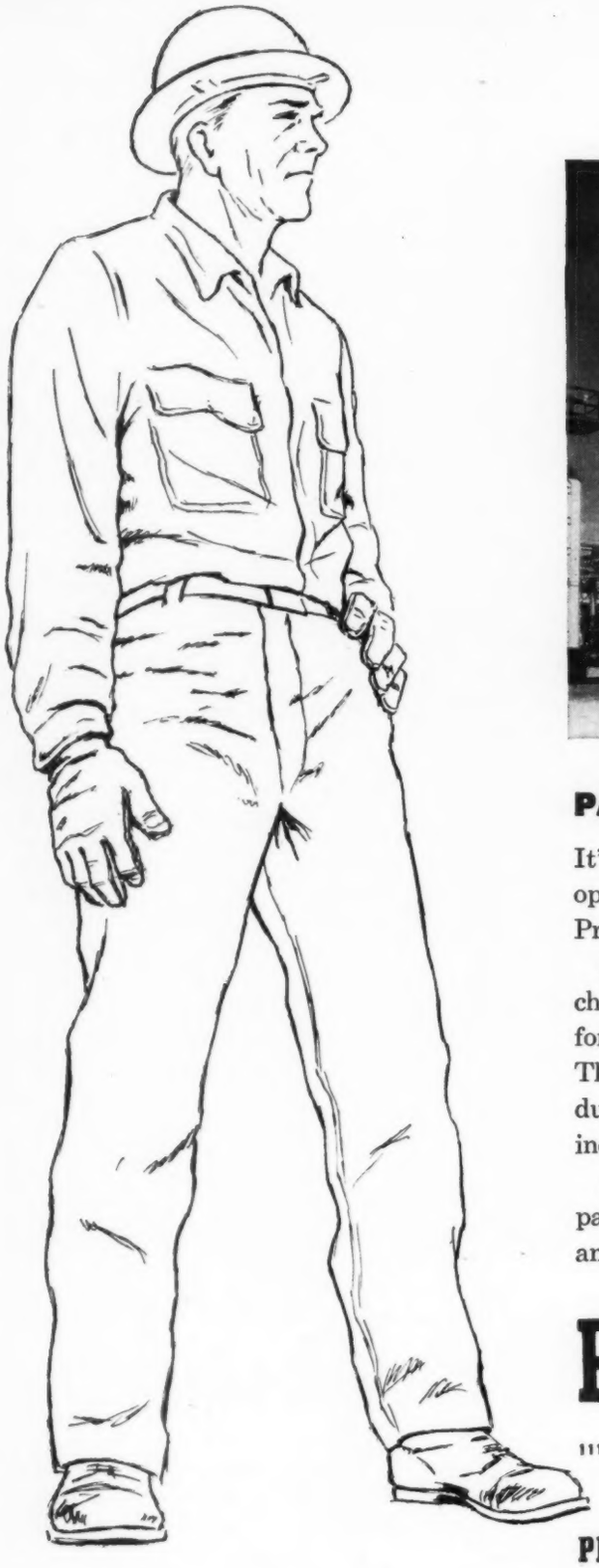

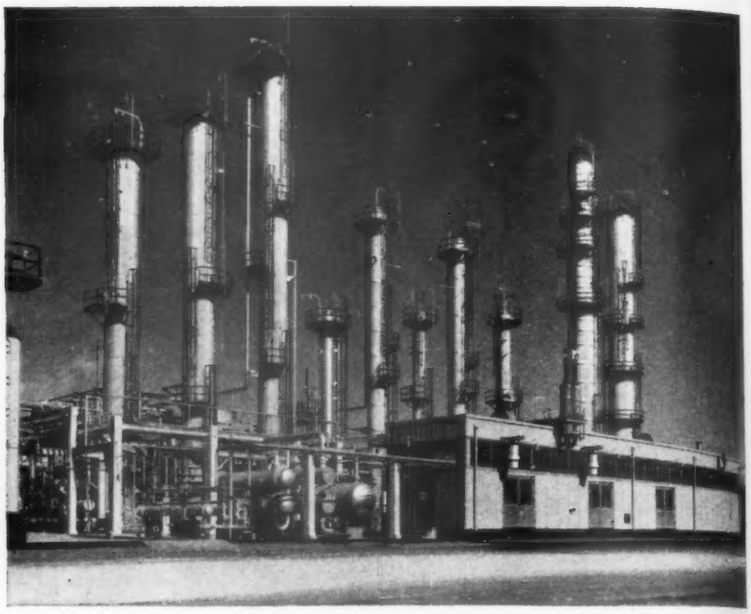

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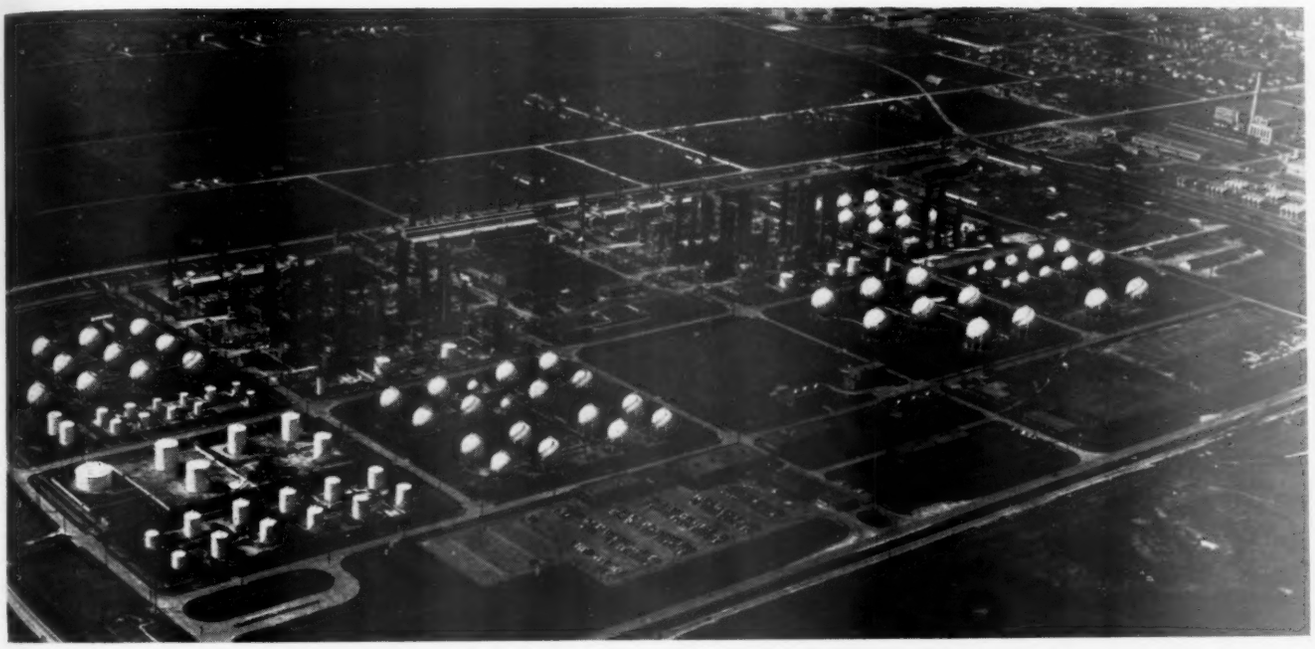

Aerial view of the famous "double" butadiene plant, Neches Butane Products Company, Port Neches, Texas.

Lucien O. Crockett
Manager, chemical department

Rolande C. Widgery
Chemical engineer, Gulf Oil Corporation

MORE natural gasoline and LPG plants are now operating than ever before, and they are processing more gas more efficiently. As a consequence, a considerable increase in the output of natural gas liquids is resulting.

The petroleum refiner can offer little comfort in the solution of these problems. He has similar problems of his own. His refineries are creating more off-gases and are, therefore, also providing more material for LPG markets. Catalytically cracked gasolines are also more volatile than those of a few years ago and are reducing the need for natural gas butanes. With supply increasing and some markets declining, it is logical that the natural gasoline producer should begin to search for new and more profitable outlets. One of the most promising directions in which he can turn is to the chemicals that can be made from his products.

The natural gasoline producer supplying raw materials to petrochemical plants has a market that varies little from month to month. Because of the high investments, such plants require year-round operation, even though the chemical products (for instance, ammonia or ethylene glycol) may have highly seasonal markets. Large petrochemical plants create the concentrated, large-volume markets for LPG that make attractive the use of liquid-product pipe lines to eliminate expensive rail or truck transportation.

To reap the advantages of petrochemical markets, however, the natural gasoline producer need not engage directly in the production of chemicals — a field which may well intimidate him with its complexity and high investment costs. It may be possible for him to profit by simply providing raw materials to the more experienced petrochemical producing company. For most operations, the chemical producer requires large volumes of specific close-cut fractions, and the natural gasoline producer can participate by providing the closely controlled fractions required for petrochemical operations.

There is perhaps also important long-term significance in the use of natural gas and natural gas liquids as chemical raw materials. As mentioned by Eugene Ayres, "several decades after natural gas and natural gas liquids have ceased to be an important fuel,

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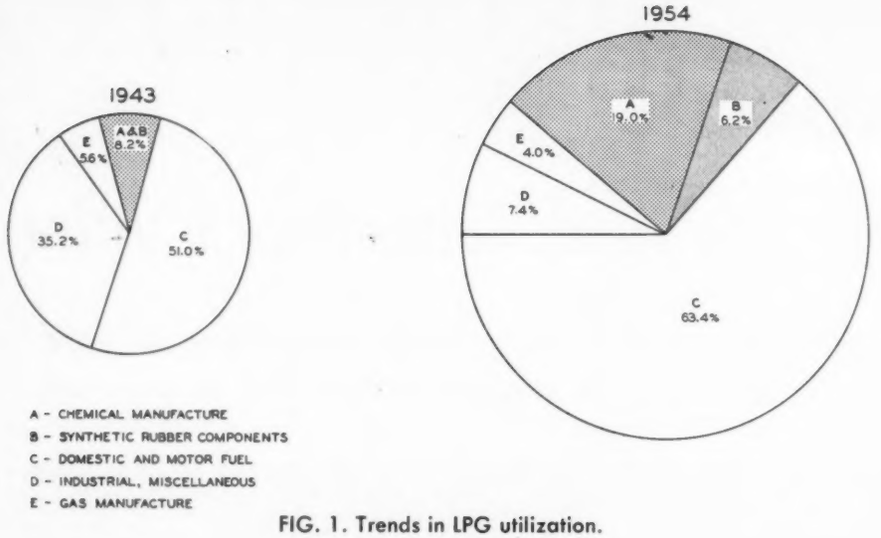

FIG. 1. Trends in LPG utilization.

they will be sufficiently abundant to continue as important starting materials for chemicals, even though they may not be obtainable at the relatively low cost that now makes them attractive."[1] The natural gas processor who has built up plant and experience in petrochemicals will be, when such time comes, in a better position to operate profitably than the fuel processor.

To summarize — the use of natural gas liquids and natural gasoline as raw materials by the chemical industry may have several advantages to the LPG and natural gasoline producer. Petrochemical projects permit upgrading of end products, a higher return on investment, a reduction of storage problems, and an increase in the proportion of flat-load sales. In the long term, they may permit a natural gas processing company to become established in the field in which natural gas liquids probably will find their principal use after they have become uncompetitive for many fuel markets.

You will notice that I have used the words "may" and "can possibly" in the above description of the opportunities open to the natural gasoline producer. This is because he will not be alone in the field. Many petrochemical and chemical companies have been hard at work in the petrochemical field and have already established large research, manufacturing, and sales organizations that are now experienced in meeting the problems peculiar to this business.

To compete in this field, the natural gasoline producer will have to engage in considerable research and will have to organize production and sales forces capable of solving the more technical problems involved.

The petrochemical industry has grown rapidly in recent years, and it is now estimated that more than 80 per cent of all aliphatic chemicals and almost 50 per cent of our aromatics are made from petroleum and natural gas hydrocarbons. More than 80 per cent of our synthetic rubber, almost 80 per cent of our synthetic detergents, more than 75 per cent of our fertilizer ammonia, and 75 per cent of our industrial alcohol are produced from this source.

In 1953, petrochemical production reached 12,650,000 tons, with a value of approximately $3,000,000,000, almost one-half the total value of all chemical production.[2] Most predictions indicate only a slight reduction of the rate of growth that has been evidenced during the last 20 years. In other words, a 150 to 170 per cent increase in production is expected in the next two decades. Even with this rapid growth, it is estimated that only about 5 per cent of our crude oil consumption and about 8 per cent of our natural gas will go into chemical production. The situation with LPG is quite different, as already almost 30 per cent of LPG sales are for chemical and rubber manufacturing applications, and this is expected to increase further (Fig. 1).

Let us, therefore, look at some of the more important chemical derivatives of natural gas and natural gas liquids and see what they are, in what ways they are used, and if they can be expected to continue to grow.

First, I wish to talk about the material that constitutes the bulk of the natural gas stream, methane, from which a large and growing number of chemicals are being produced (Fig. 2). Probably the most publicized at the present time is synthetic ammonia, with almost 2,500,000 tons per year capacity already built and more plants under construction.

Closely related to ammonia is methanol, one of the largest-volume organic chemicals. Methanol appears to have reached a plateau in its demand curve, and since ammonia plants can be readily converted to methanol production, any significant additions to methanol capacity are unlikely.

Acetylene, another product of nat-

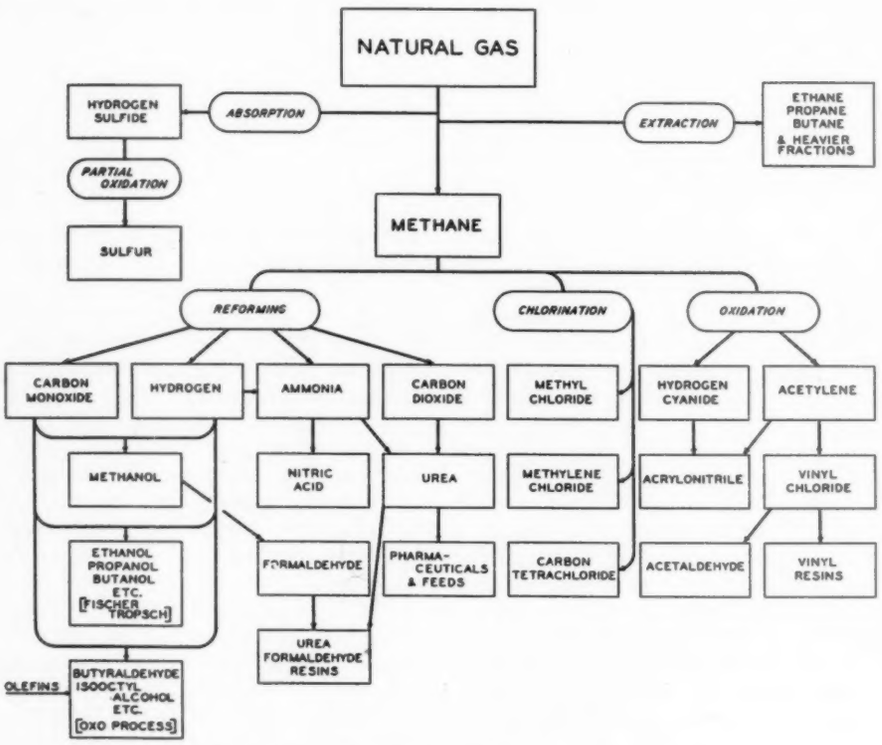

FIG. 2. Derivation of chemicals from natural gas.

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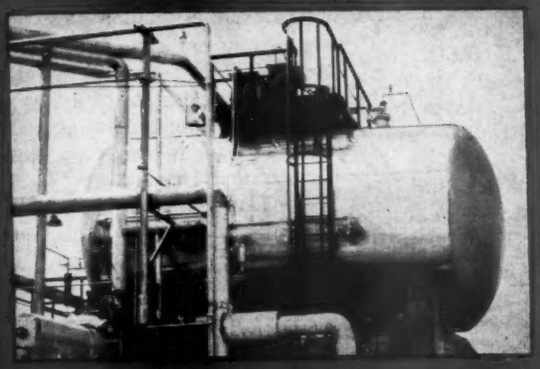

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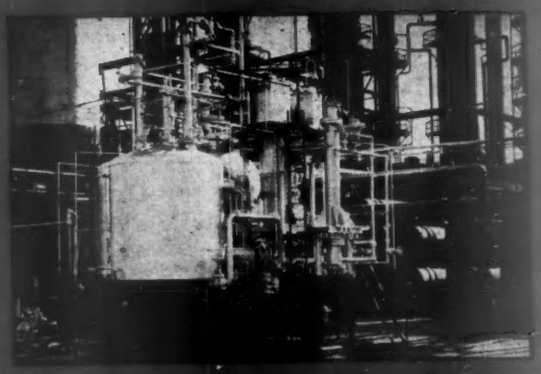

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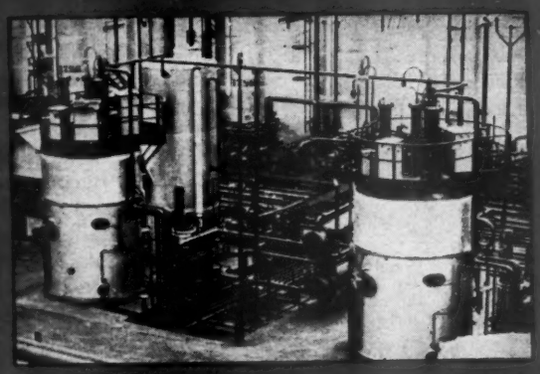

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ural gas that has been in the news, is a source of many materials such as vinyl plastics, acrylonitrile, and acetaldehyde and is the potential source of many complex and valuable chemical products. Contrary to many hopes and several predictions, however, it has to date been impossible to produce really low-cost acetylene from natural gas.

Several other derivatives of natural gas, such as carbon disulfide, hydrogen cyanide, nitromethane, methyl chloride, methylene chloride, and carbon tetrachloride are required in smaller plants. These and others might be considered by companies wishing to set up small-scale petrochemical operations based on natural gas.

Almost 400,000 tons per year of sulfur are recovered from hydrogen sulfide removed in sweetening natural gas. Under present conditions, only plants yielding at least 20 tons a day are economically attractive in most areas.

Hydrocarbons included in natural gas liquids are almost entirely of the series known as paraffins or saturated hydrocarbons. These can be converted to chemical building blocks, for example, by cracking to the more reactive olefins or by chlorination. The natural gasoline producer, therefore, is one step further away from a saleable chemical than the petroleum refiner, since a large percentage of refinery gases are reactive olefins.

Ethane-Propane

Let us now turn our attention to ethane and propane, which can be used more or less interchangeably in the production of a variety of chemicals.

The principal products that can be prepared from ethane-propane fractions are ethylene and propylene.

A recent article estimates about 50 per cent of this country's ethylene is produced from propane, 40 per cent from ethane, and 10 per cent is extracted from refinery gases.

H. A. Mitchell, who estimates a total annual ethylene demand of about 3,000,000,000 lb by 1956, believes that considering the probable availability of refinery gases, 18,000 bbl per day of LPG propane will be required for cracking to ethylene in that year.[3] Our estimates indicate that the latter figure is very conservative. As chemical and other demands for propane increase, however, it will be profitable to recover ethane from natural gas streams for the production of ethylene.

Bateman and Ragland have estimated that 15,000,000,000 lb per year of ethylene could be manufactured from ethane contained in natural gas.[4] Although there is a large potential supply of natural gas ethane, the chances are slight for the recovery of more than a small portion. Except in special cases where tremendous quantities of ethane are collected in one gas stream, the situation is generally unfavorable for producing ethylene from natural gas ethane.

Data indicate that small-scale ethylene plants are at a severe handicap costwise compared with large plants. This size factor holds, of course, with ethylene produced from propane.

A specific example of the large size plants which have been built to convert propane to ethylene is that recently added to the Gulf ethylene producing system at Port Arthur (See Fig. 1). This plant has a capacity of 220 million pounds per year.

Representative of large-scale operations based on natural gas ethane is the plant recently built at Tuscola, Illinois. This plant, which draws its feed from an important transcontinental pipe line, recovers these hydrocarbons by processing 425,000,000 cu ft of gas per day (Table 1).

TABLE 1.
Operations at Tuscola, Illinois

Hydrocarbons Recovered	
Ethane, scf/day	10,000,000
Propane, gal/day	380,000
Isobutane, gal/day	21,300
Normal butane, gal/day	57,400
Gasoline, C_5+, gal/day	18,520
Intermediates from Ethane	
Ethylene, lb/day	600,000
lb/year	200,000,000
Hydrogen, scf/day	8,000,000
Primary Products from Ethylene	
Ethyl alcohol, gal/year	40,000,000
Diethyl ether, gal/year	3,000,000
Ethyl chloride, lb/year	50,000,000
Polyethylene, lb/year	25,000,000

Ethylene Uses

Traditionally, the largest consumer of chemical ethylene has been synthetic ethyl alcohol, which is estimated to have required over 600,000,000 lb in 1953 (Fig. 3). Synthetic ethanol is an interesting example of a case in which a petrochemical has gradually supplanted a chemical based primarily on agricultural by-products.

One of the most interesting and potentially one of the largest outlets for ethylene is polyethylene, sometimes known as the "squeeze-bottle" plastic. This extremely versatile plastic is now undergoing a great expansion, with an estimated ethylene requirement of 600,000,000 lb in 1957. Nine companies have recently completed or have under construction facilities for polyethylene production, and we are going to see more of this material in familiar uses such as packaging, piping, and molded articles, as well as in many new applications.

One of the more ingenious uses of this material in the home is a plastic tube that is expected to compete favorably with collapsible metal tubes for dispensing small amounts of products as cosmetics, glues, inks, etc.[6]

You may be interested to know that sheet polyethylene has been used successfully in wrapping natural gas pipelines.[7] Its advantages are light weight, permanent flexibility, excellent resistance to moisture transmission, and ability to resist almost any type of corrosion.

The second largest current use of ethylene is in ethylene oxide and its main derivative, ethylene glycol. A period of extremely rapid expansion has resulted in some over-capacity in this industry, and it is expected to be several years before additional capacity is required. The most important use for the glycol is as an automotive antifreeze. Ethylene required for glycol amounted to almost 600,000,000 lb in 1952, but requirements fell to 475,000,-

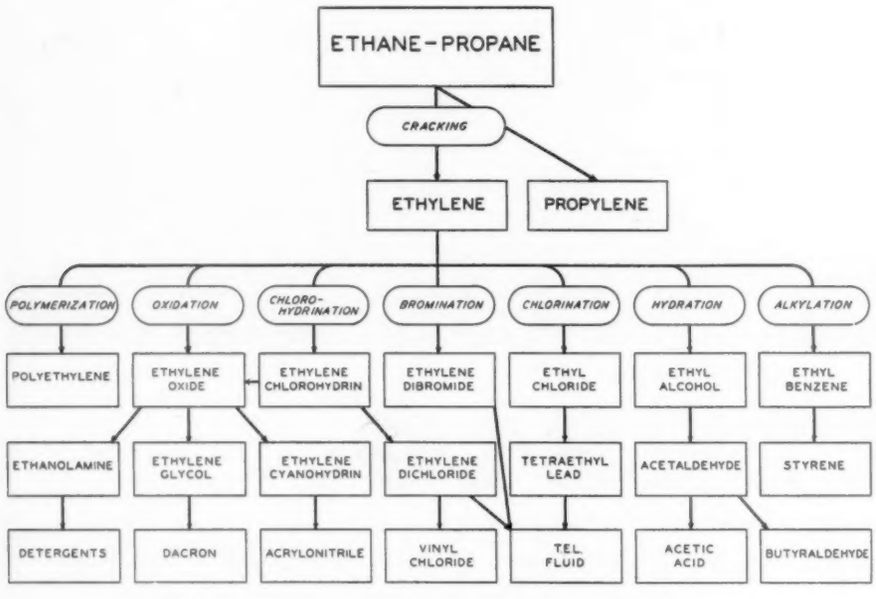

FIG. 3. Ethane-propane derivatives, through ethylene.

000 lb in 1953, and rose only slightly to about 500,000,000 lb in 1954. This shows that even petrochemical markets have their ups and downs.

The reaction of ethylene oxide with ammonia produces the ethanolamines. You are probably most familiar with these because of their use in gas scrubbing to remove hydrogen sulfide and carbon dioxide, but they have also met with good reception in the production of certain types of detergents.

Another market for ethylene oxide is in the production of acrylonitrile, used in several popular synthetic fibers and in nitrile rubber. In this application, ethylene comes into direct competition with acetylene, making it difficult to estimate future ethylene requirements for this use.

Ethyl chloride is used in the production of tetraethyl lead, and ethylene dichloride and dibromide are incorporated in tetraethyle lead fluids, which, as you know, are used in large quantities for octane improvement of automotive and aviation gasolines.

Another market for ethylene is in the production of styrene, important in the production of plastics, synthetic rubber, and latex paints. Many smaller outlets for ethylene could be mentioned, but time does not permit.

Propylene

The most important products made from propylene are isopropyl alcohol, acetone, glycerin, propylene glycol, and the propylene polymers (Fig. 4).

Isopropyl alcohol is the largest of these, and its production amounts to some 900,000,000 lb, of which about 60 per cent is used in the production of acetone, most of which is used in producing cellulose acetate fibers, films, and lacquers.

The production of synthetic glycerin from propylene, another triumph of man's ingenuity in reproducing natural products, has been an important stabilizing influence in the glycerin market. Synthetic glycerin production helped to fill the void created by the shortage of the natural soap by-product, glycerin, ouptut of which declined due to the impact of synthetic detergents.

Propylene glycol, still another propylene derivative, is produced at about 60,000,000 lb per year, and is used as a moistening agent (tobacco), as a solvent, and with ethylene glycol as an antifreeze.

Propylene polymers are also of chemical interest. Propylene trimer is used in the Oxo process for the production of decyl alcohol, which is an important plasticizer raw material. It is also used in detergent production. Propylene tetramer is used in large quantities in the production of one of the largest selling detergents. If the tetramer is used in the Oxo process, a 13-carbon alcohol is produced that is finding use as a high quality detergent intermediate.

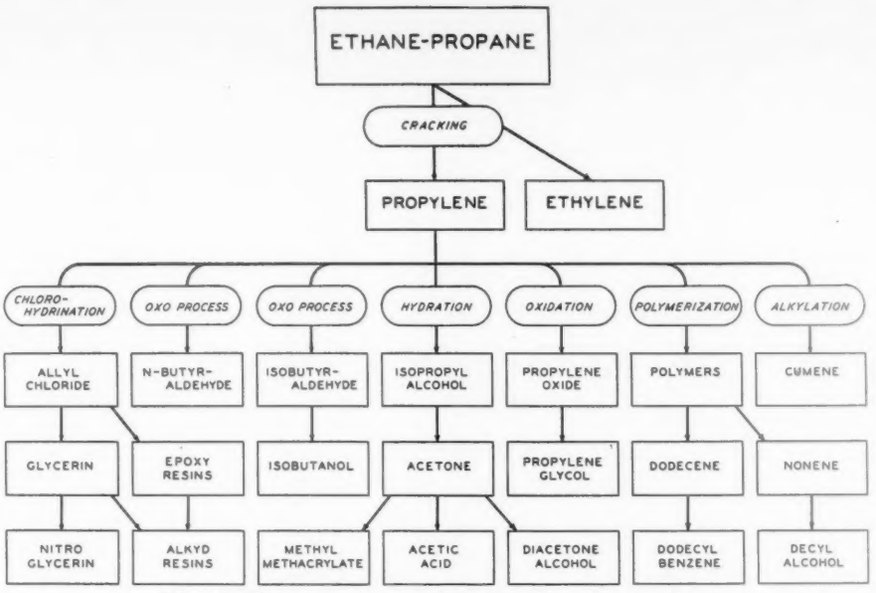

FIG. 4. Ethane-propane derivatives, through propylene.

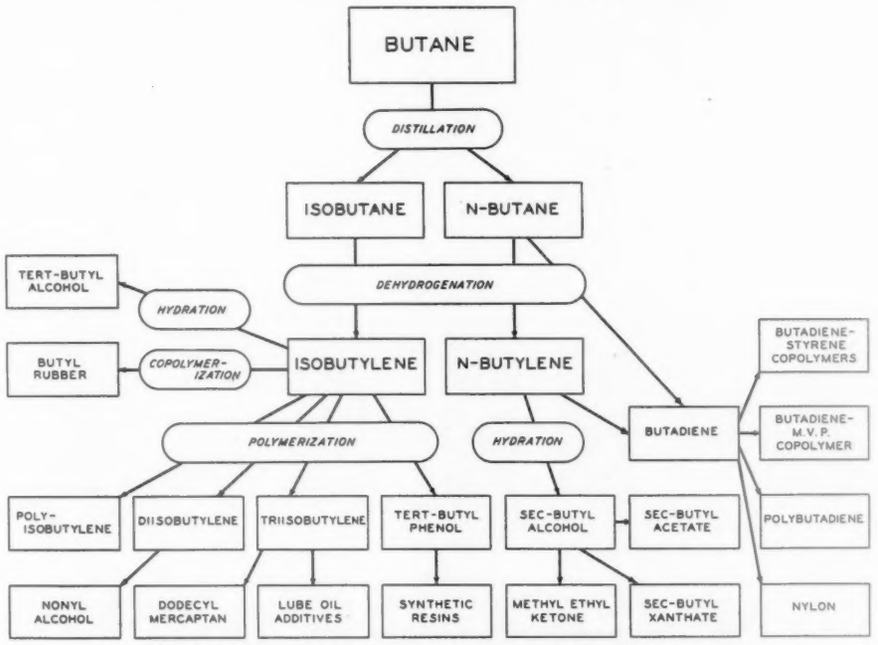

FIG. 5. Chemical derivatives from normal and isobutane.

Finally, another route through which propane can be converted to chemicals is by oxidation. By oxidizing a propane-rich gas stream, a wide variety of oxygenated derivatives can be produced. These include formaldehyde, acetaldehyde, butyraldehyde, acetic acid, propionic acid, methanol, isopropanol, and others.

The Butanes

I need not tell you that after propane comes butane. The butanes, as you know, are used in improving gasoline volatility, and sales to refiners have provided a large-volume outlet, but for the reasons mentioned earlier this market is not growing. Some interesting chemical products can be made from butanes, however, and it is probable that the extraction of butanes from LPG for chemical end uses will grow rapidly. The most significant current chemical use of butanes is in the production of isobutylene and n-butylene. It is estimated that about 140,000,000 gal per year are converted to butylenes (Fig. 5).

Isobutylene when polymerized with small quantities of isoprene makes the elastomer known as butyl rubber. Although butyl is being used in somewhat smaller quantities because of the switch to tubeless tires, the many excellent qualities of this rubber are likely to make remain an important elastomer.

As shown in the figure, a variety of isobutylene polymers can be made for use as chemical intermediates, caulk-

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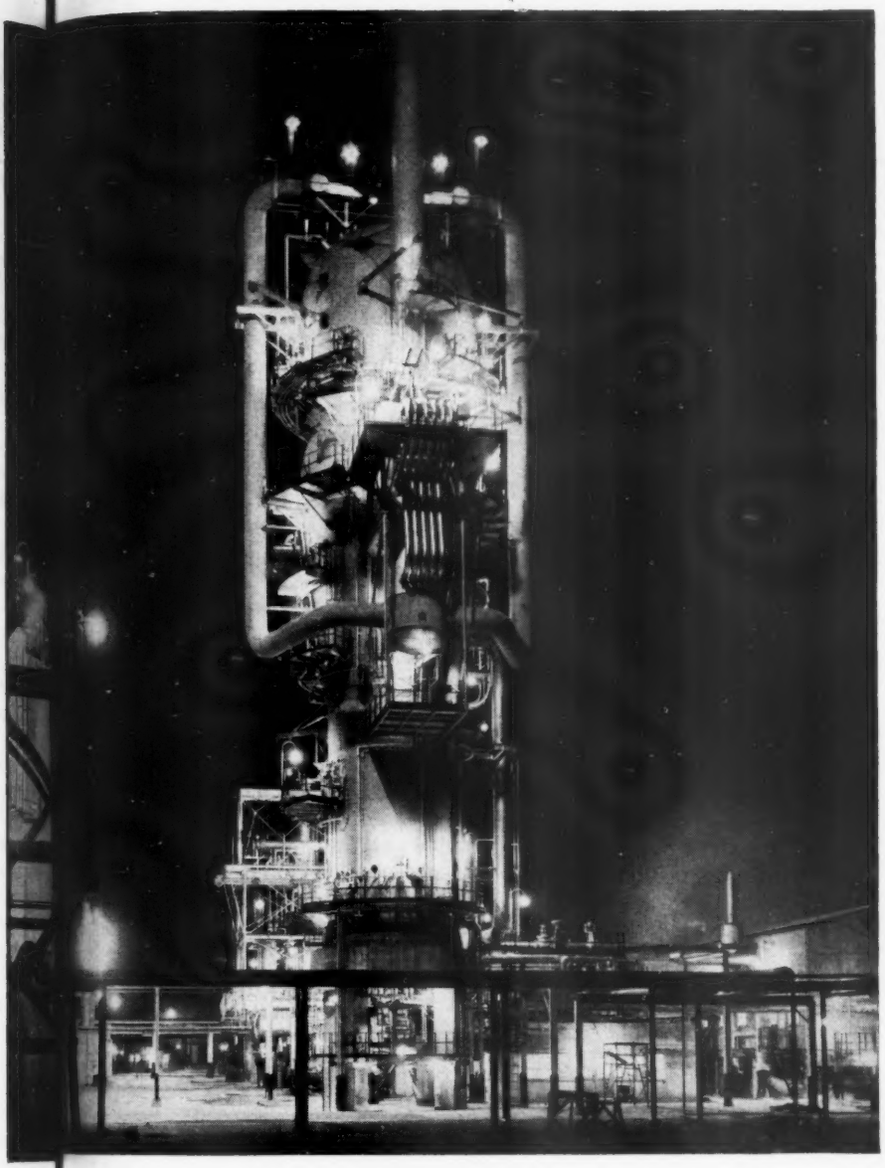

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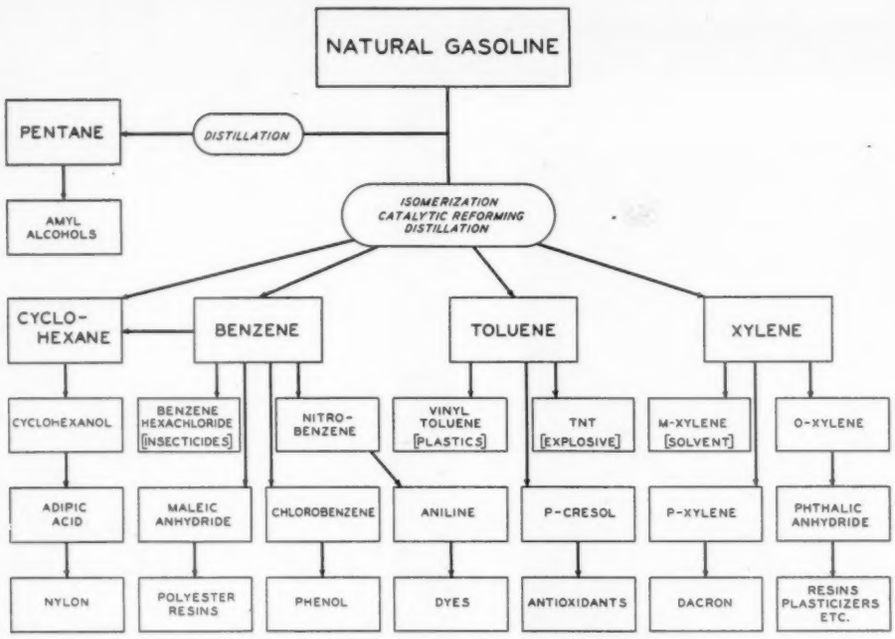


FIG. 6. Chemical derivatives from natural gasoline.

ing compounds, lubricant additives, and plasticizer extenders.

Butadiene derived from normal butylene is the principal raw material for the rubber that has for almost 15 years been called GR-S.

In GR-S production, butadiene is copolymerized with styrene, and the resulting material reinforced with carbon black and vulcanized with sulfur. The product is superior to natural rubber in tire treads and many other applications. Since the synthetic rubber producing facilities were purchased by private enterprise last April, many research and expansion projects have been undertaken to improve the quality and quantity of synthetic rubber production. In butadiene production, as in ethylene, size is important. Shown in Fig. 3 is the Neches Butane Products Company plant at Port Neches, the largest and generally believed to be the most efficient.

Some butadiene is used in the production of nylon by one firm. Another company has recently announced that a synthetic drying oil of excellent quality, called C-Oil, can be made by the partial polymerization of butadiene.[8] These and other new uses will require additional quantities of butadiene.

While most of our butadiene has been produced from refinery butylenes or by a two-stage process from natural gas butane, a process is available for the production of butadiene directly from n-butane.[9] Developments such as this are opening up opportunities for the natural gasoline producer to produce intermediate chemical building blocks of high purity that will meet ready acceptance by small and large chemical companies.

Natural Gasoline

Let us now turn our attention to the remaining products of the natural gasoline plant—those above butane (Fig. 6). These are usually classed together as natural gasoline. Chemically, the most important are the cyclic and aromatic fractions that are either present as such or can be produced by catalytic reforming. The principal use for these of course, is to improve the octane rating of gasolines for, as was remarked recently, "Gasoline has really become the world's greatest outlet for petrochemicals."[10]

Under some conditions, the extraction of specific chemicals can be warranted. Principal among those now recovered are cyclohexane, benzene, toluene, and xylenes. Cyclohexane is an important raw material for the production of adipic acid, an intermediate in the production of nylon.

Benzene, which until the last few years was considered entirely a coal tar chemical, has many uses. It is used in the production of styrene, phenol, aniline, maleic anhydride, and many other important intermediates in the manufacture of plastics, insecticides, disinfectants, dyes, pharmaceuticals, and an almost endless list of other products.

Toluene is usually thought of as a component of aviation gasoline, as a

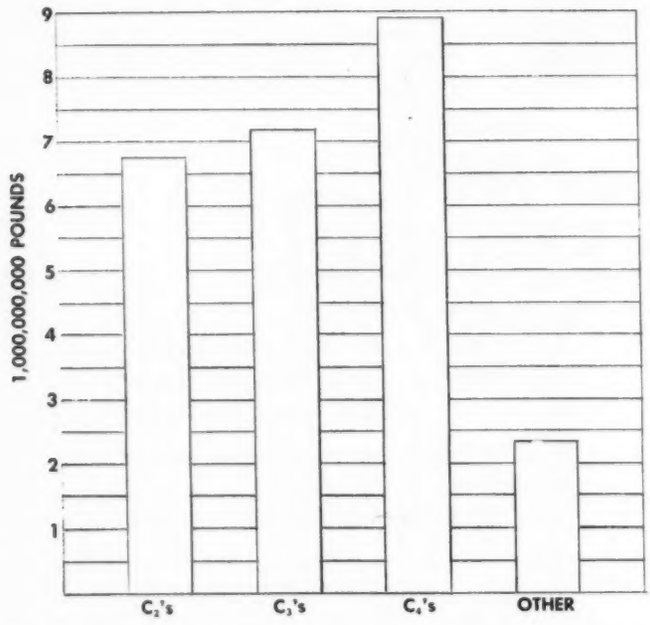


FIG. 7. ALIPHATIC HYDROCARBONS. Crude products from petroleum and natural gas—(Source; U. S. Tariff Commission, preliminary figures). For chemical conversion, 1954.

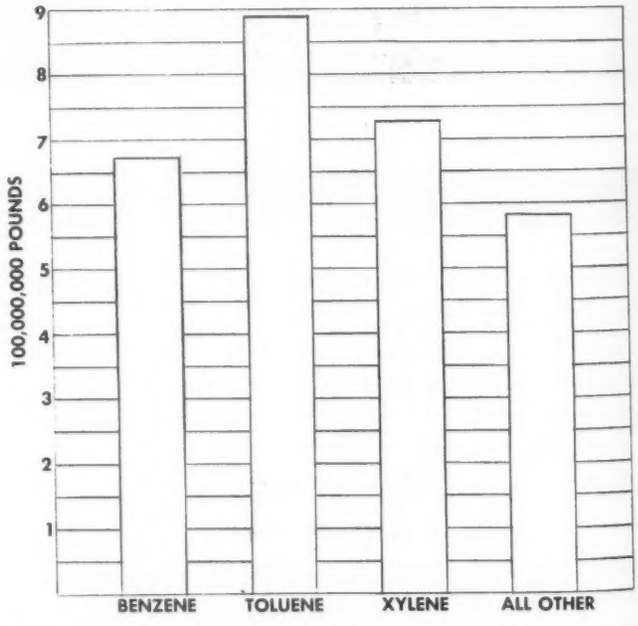


FIG. 8. AROMATIC HYDROCARBONS. Crude products from petroleum and natural gas, for chemical conversion, 1954. (Source; U. S. Tariff Commission, preliminary figures).

raw material for explosives production, or as a solvent, which normally offer limited and low value outlets. There are several possible routes, however, by which toluene can be converted to higher-priced materials, as is evidenced by the fact that two large companies have recently begun the production of vinyl toluene for use in thermoplastics and surface coatings, and that a third is producing para-cresol from toluene starting material.[11]

The xylenes provide an example of how a petrochemical fraction can be developed as a chemical raw material. Although the mixed xylenes were used almost solely as a solvent prior to World War II, methods to separate the isomers were developed, and each of them is now of commercial importance.

Para-xylene is now an important raw material for the fiber, dacron. You have no doubt heard of the way in which dacron suits and ties can be washed and dried without ironing and still look as though they had just been pressed.

Ortho-xylene is competitive with naphthalene in the production of one of the chief intermediates in paints, resins, and plasticizers.

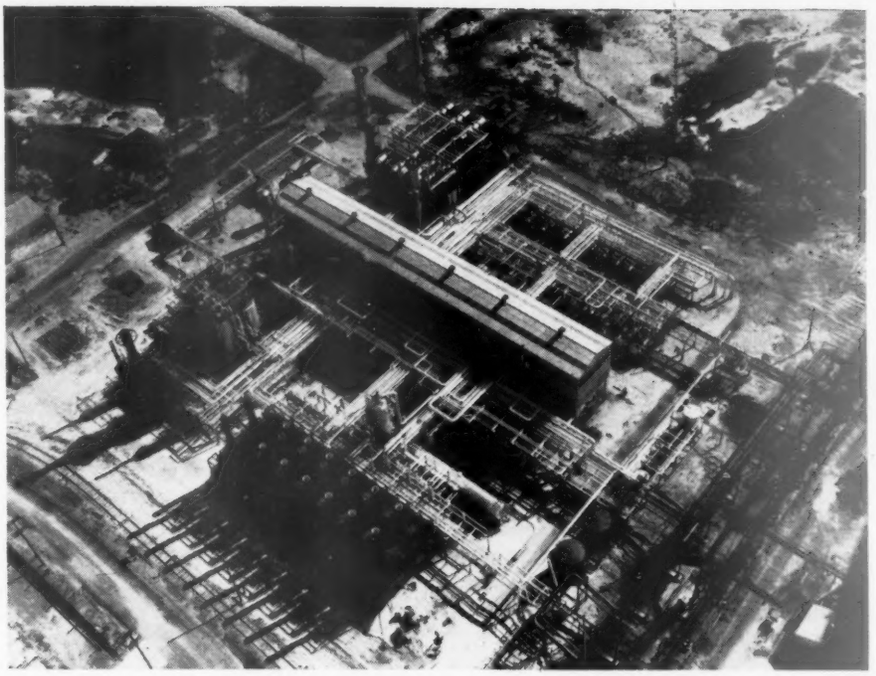
The third isomer, meta-xylene, is finding use in the production of isophthalic acid, which, while similar to phthalic anhydride, is said to be superior in some applications.

I have discussed some of the reasons why natural gasoline and LPG producers should consider petrochemicals and have looked at a few of the more important chemical products that can be made from natural gas, LPG, and natural gasoline fractions. There are probably some of you thinking, "this is all very well, but how do we start and what does it take to get into the business?"

One of the attractions of petrochemicals is the possibility of increased return on capital investment in comparison with the processing of fuels. As you all know, the rate of return on investment has a way of being roughly proportional to risk of the project. Petrochemicals have no special license to deviate from this generality.

The principal risk, and the one over which there is the least control, is that some smart competitor may develop a better product or a much lower cost process with the consequent possibility that one's own product or process may be suddenly outmoded.

Another risk is that of failing to make the necessary "mental adjustment" to the dimensions of the new business. When the natural gasoline producer embarks on a petrochemical venture, he must remember to keep in mind that in this field he must think in terms of pounds per day rather than millions of cubic feet or thousands of gallons. This matter of mental adjustment is very important. It must control his approach to problems ranging all the way from plant design through plant operation to sales policies and methods. If the difference is kept in mind by all concerned, the chances for success in the chemical field will be improved.



View of the second ethylene plant of Gulf Oil Corporation, Port Arthur, Texas, that just recently went on stream.

Perhaps the best way of estimating what might be done is to look at what has been done. While the petrochemical industry is scarcely thirty years old, in this brief space of time more than 145 companies have become established. Sixty of these are oil refiners and many others are established chemical companies. The lure of petrochemicals, however, has induced a number of firms from other lines to invest in this field; namely, a distiller, a farm equipment manufacturer, and a shipping company, all having little or so apparent connection with either petroleum or chemicals prior to their entrance into the field. It is expected that still others will also be attracted by the "growth potential" that is still characteristic of most areas of the petrochemical business.

Petrochemicals, with an annual dollar value of more than three billion a year, represent almost half of the total value of all chemical production from all sources in the U. S. They have accounted for almost 80 per cent of the organic chemicals produced in this country in recent years, and this percentage is expected to increase.

There have, of course, been some failures and these stand out from the field by the very fact that their performance has been so different from that of most companies that have embarked on petrochemical endeavors. Generally, it is believed that lack of research, design engineering, and pilot plant testing are often responsible for such failures. Most companies one thinks of in connection with petrochemicals, however, have been able to show satisfactory profits and have increased their investment in the field by diversifying and expanding operations. The final question is how have these firms succeeded in the petrochemical business. The answer is the same as for any successful business—planning, money, and work.

Planning includes the analysis, development, and integration of choice of site, process, product, and market. Without a thorough study of each, the chances that the project can be successful are reduced. The site must have advantages with regard to raw material, fuel, water supply, labor, and access to favorable markets, or a reasonably good combination of these. The process, ideally, should be proved workable and able to yield a product as low or lower in cost than those of competitors. The plant should be flexible to permit economic operation at a low percentage of capacity and adaptable to the manufacture of other products. Markets must be thoroughly and continuously studied to determine that there is a ready acceptance for your product, that the price will be adequate and stable, and that you may be aware of any danger of your product being supplanted by other new or different chemicals that have come upon the scene. The results of each of these studies must be integrated and pre-

sented to management in clear perspective prior to the time for planning the financing of the project.

Another method of getting into the petrochemical industry, of course, is to buy an operating company. This is more of an investment matter than one of capitalizing upon a basic raw material supply position.

In these days, we see that rubber, paints and varnishes, fibers, leather, wood, and even steel are having to hand over large or small portions of their markets to products based on petroleum with better products resulting. These changes are going to require ever increasing quantities of petrochemicals. A clearly thought out program for supplying petroleum raw materials from which still larger quantities of lower cost, better quality end products can be made should have an excellent chance of success.

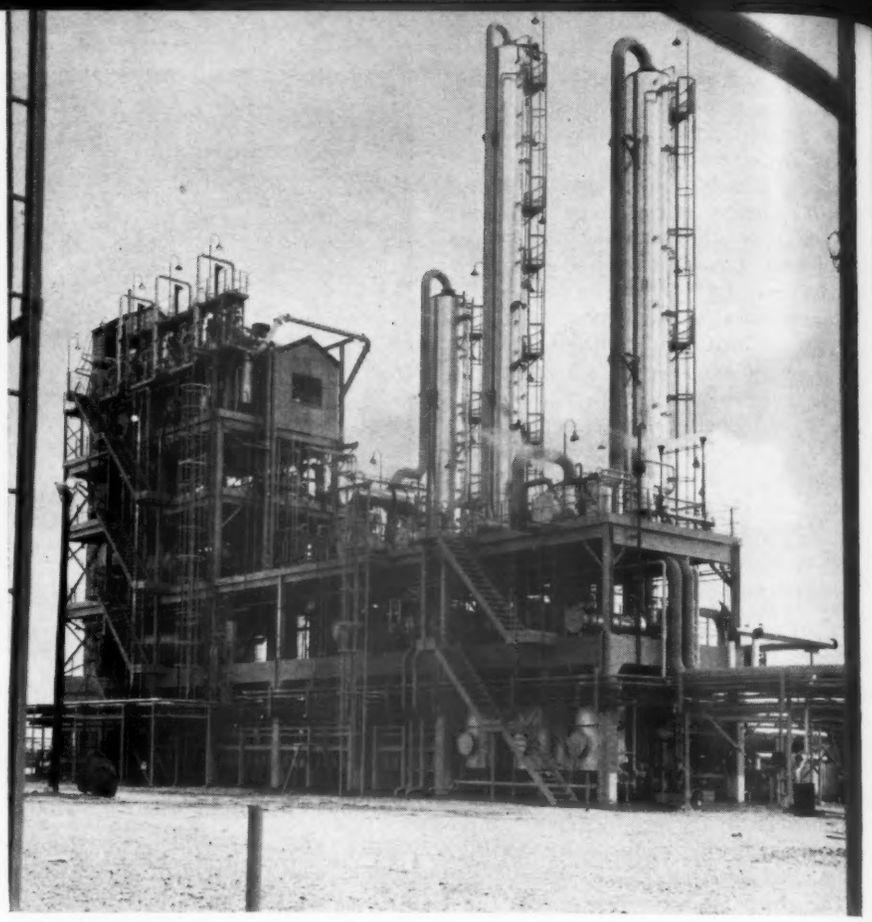
If you elect to become a supplier of high-quality raw materials or of large-volume basic intermediates, your position is much less vulnerable to the impact of rapid technological changes than that of the producer of the higher priced, smaller volume chemicals. For instance, it has recently been revealed that the cost for research and testing of each organic insecticide successfully put on the market by one of our larger chemical firms is about $1,000,000. After this investment has been made, the plant must be built, and yet the possibility remains that the product may be overshadowed by some newer and better wonder killer in a matter of months.

You may feel that the golden era has passed and the 140 or so companies that have entered the field have skimmed the cream from petrochemical opportunities. This is not the case. There are ever developing opportunities based on new chemical discoveries that open the door to the production of new and better products. While, as discussed above, there are certain fields in which size is of utmost importance for competitive operations, there are other markets in which smaller volumes of materials are required, such as mercaptans, chlorinated methanes, nitroparaffins, pentaerythritol, etc., in the production of which profits may actually be better than those in extremely "high-volume" markets.

The petrochemical project best suited to your operations may not be easy to decide upon. There is every sign, however, that time and money spent in research and planning to find the best products, the best processes, and the best markets, will bring great rewards in reduced risk, fewer mistakes, smoother operations, and higher profits when the plant is built.

I thank you for your patience—I probably have told you nothing new, but hope that some of my information and ideas have been of interest and may prove of help to you in the future. As you know, I am speaking from a background of oil refining and from current experiences in the petrochemical business. The rapid expansion of this business over the past several years and the optimistic predictions for its long-range future sometimes baffle me. I think that the main point I have attempted to make is that when entering into this deal, we should do so with awareness of all the factors involved, adequate financing, and tireless determination.

It seems to me that perhaps the best route to success in petrochemicals is by way of converting oil and gas brains to petrochemical thinking and by the cautious investment of capital funds in some of the more conservative types of chemical projects. After you have established a petrochemical operation, there will be time enough to take on the added risks inherent in more speculative projects. There are some venturesome people who, with little prior experience in the chemical field, may be inclined to take on the large risks of investing in complex plants. Such people make headlines, of course, but sometimes not of the best kind.



Recently completed plant where ethylbenzene, styrene intermediate, is made by combining ethylene with benzene. Koppers Company.

I would like again to emphasize the importance of research and development in the chemical business. It is probably even more important in this business than it is in the oil and gas business, and you know it is not a subject that we in petroleum refining take lightly in these days of severe product competition. It is extremely difficult and perhaps foolish to enter into any phase of the petrochemical business without a well-founded and well-staffed research organization.

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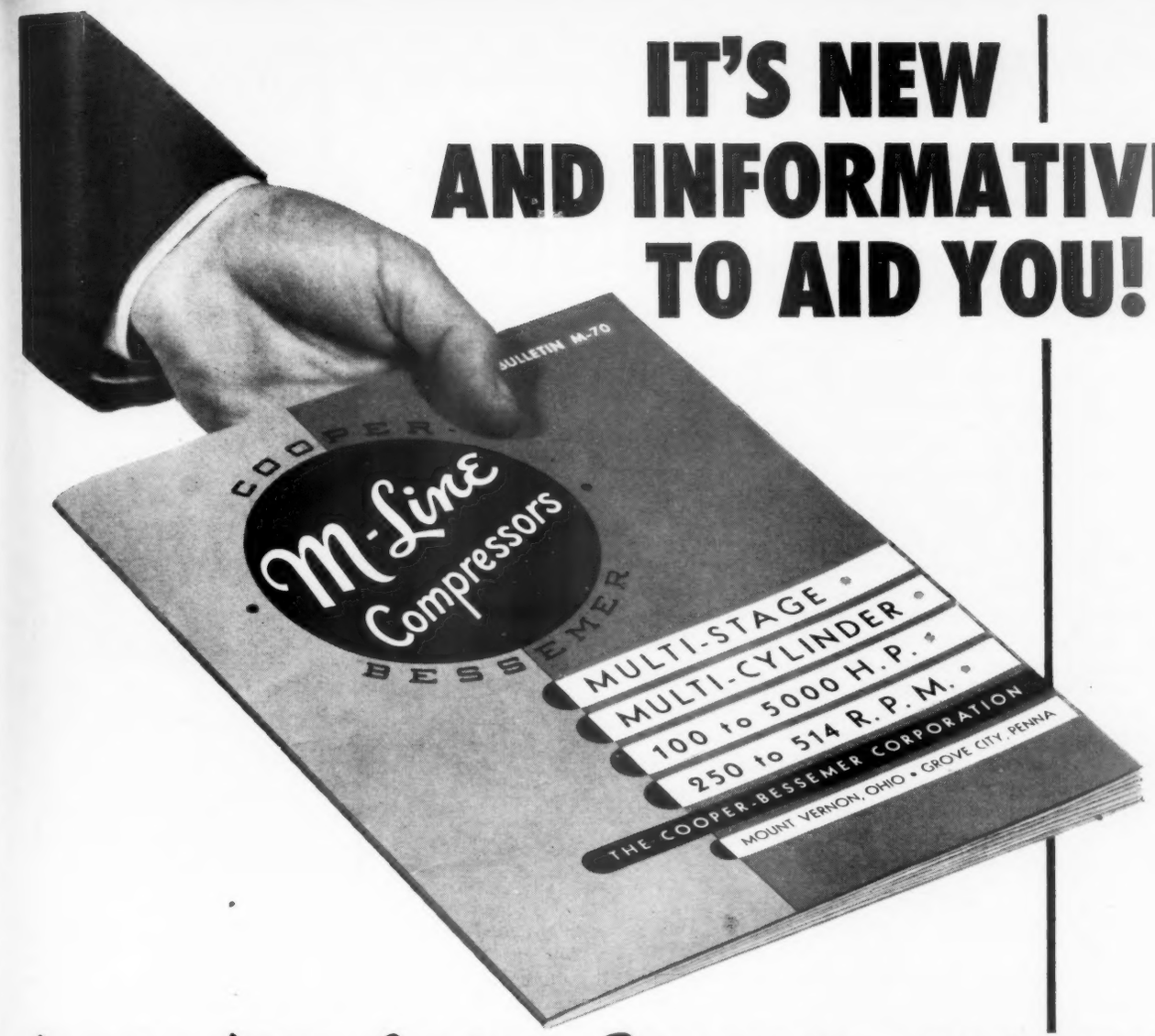

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Analytical Methods

Analysis of Gaseous Mixtures With a New Unit

K. H. Clough

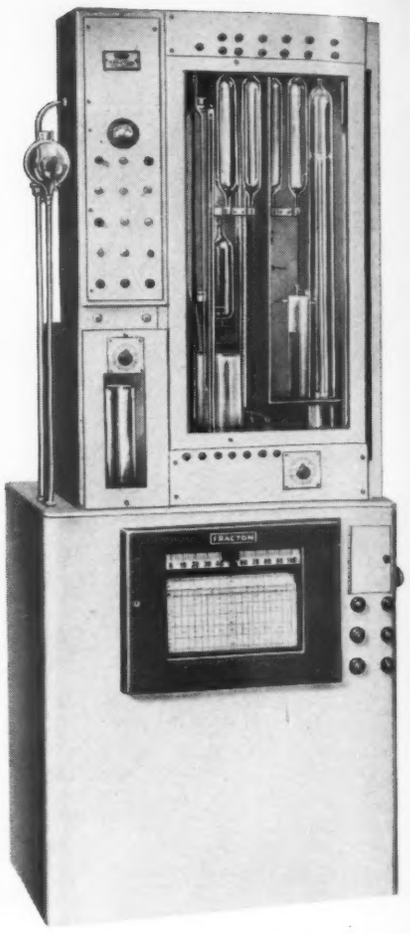

FIG. 1. Front elevation of Fracton, showing column, absorbers, lines, etc.

THE ever-expanding petroleum and petrochemical industries have necessitated many new tools to aid in the solution of their complex and increasing analytical problems. One of these problems is that of precise and rapid analysis of gaseous mixtures, or mixtures that would be in the gaseous phase under a controlled set of conditions.

The Fracton was designed to utilize the well known preferential adsorption of gases on an activated surface, together with subsequent displacement of these gases by a selected heavy gas whose affinity for the adsorbent is greater than that of any of the components to be determined. Identification of the individual components is accomplished by thermal conductivity measurement and quantitative percentages determined by drive manometric technique.

Method

Fig. 1 is a photograph of the instrument and Fig. 2 shows a flow diagram.

A tapered glass column "F" is first packed with fine uniformly sized particles of a highly activated charcoal. Firm packing insures against channeling and provides maximum surface contact. The tapered design of the tube provides high capacity with best separation of constituents with minimum capacity near exit of gas from the column to the thermal conductivity cell "G." After packing, each column is placed in a desorber, Fig. 3, where it is heated under vacuum to approximately 500 C for 4 hours. This serves to degas the charcoal and to render it highly adsorbent. The columns are sealed while hot by special connectors.

Very little has been written regarding column preparation, and yet it is one of the most important steps in obtaining good analytical results. Three different procedures may be employed after the column has been degassed. Columns may be used immediately after cooling, in which case they are called "vacuum columns," or they may be filled to a positive pressure with neon gas before cooling or with nitrogen gas after cooling, in which cases they are referred to as gas-filled columns and the neon or nitrogen respectively are referred to as "fill" gases.

A vacuum column may be used for special applications, such as for use with a sample containing hydrogen or for a sample containing extremely high percentages of methane. Hydrogen would tend to diffuse with a "fill" gas and give a curved rather than a straight thermal conductivity line. In the case of samples with 90 per cent or greater of methane, the use of a vacuum column would permit the methane to be taken directly through the column, and by using a large-size sample the heavier components could be concentrated in the column, thus increasing the accuracy of measurement.

The most readily available "fill" gas is nitrogen. It must be added to the evacuated column after the column cools and is usually added at a pressure of 2 lb. Nitrogen can be used as a "fill" gas for most analyses, the main exception being that it cannot be used where samples contain hydrogen, carbon monoxide, nitrogen, or oxygen, as it would interfere.

Neon, on the other hand, does not present this objection. It may be added to the column while the column is hot. The pressure used is about 30 lb, which leaves a residual pressure above atmospheric when the column cools. Its only disadvantage is that it is not as readily available and that the initial cost of a cylinder is high. Since the amount of gas used per column is quite small, the cost is low per analysis.

Columns with "fill" gas can be stored for long periods of time, whereas vacuum columns must be used while fresh. No contamination can occur in storage as the pressure in the column is always above atmospheric. LPG and natural gasoline samples can be injected directly into a gas-filled column in the field with displaced "fill" gas being vented. These charged columns can be brought to the laboratory and analyzed without worrying with sample bombs, bottles, leaky valves, and possible change in composition as the columns are sealed and the samples remain adsorbed on the charcoal until displaced. Sampling procedures have been thoroughly discussed in a previous paper.

Mixtures to be analyzed fall into three groups: (1) Gas-phase samples, (2) liquefied gases under pressure, and (3) samples that are liquid at temperatures near atmospheric but which will be in gas phase at operating temperature. Gas-phase samples are charged to the Fracton by taking the sample into Burette "A" Fig. 2, where it is measured over mercury. Approximately 300 to 350 ml samples are normally used. Gas samples are passed into the column "F" by opening valves 2 and 6 and raising the levelling bottle to permit pressure from the mercury to displace the sample from the Burette at a selected rate of approximately 35 ml per minute. LPG examples and liquid samples are injected directly into

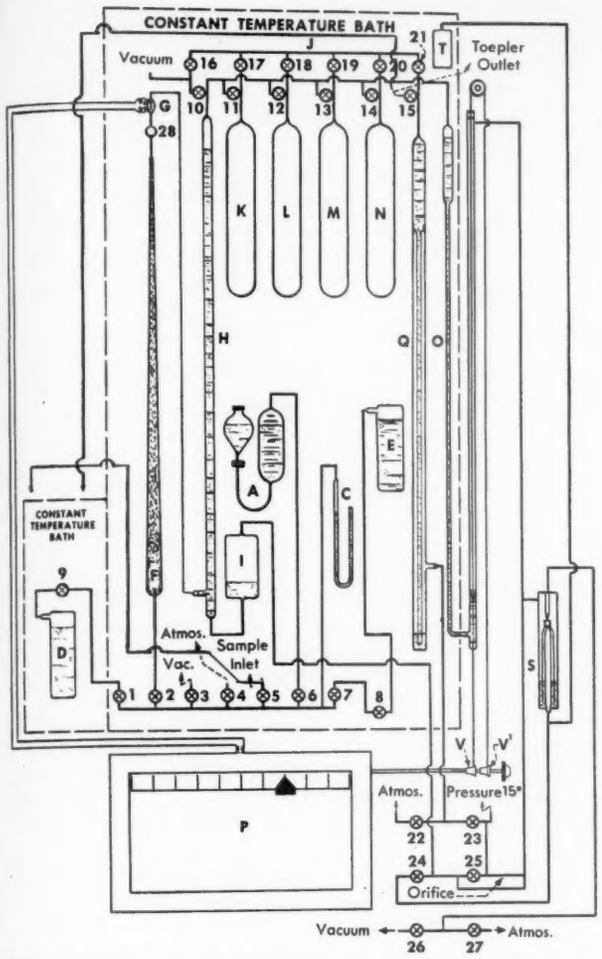

FIG. 2. Flow diagram of the Fracton routine of analysis of gaseous mixture.

the column before the column is placed in the instrument.

The entire main cabinet of the instrument is a thermostatted constant-temperature bath with the heating elements in the walls. A blower maintains circulation and even temperature throughout bath. Two temperatures, 72 C and 105 C, are available by means of a switch on main control panel.

Two displacement liquids are used. One called DL5 is used for analyses through pentanes and the other, DL8, is used for analyses through octanes. The DL5 container is mounted in a small thermostatted constant-temperature bath to the left of the main cabinet. The temperature of this bath is maintained at 70 C, which is sufficient to insure a vapor pressure from DL5 liquid of 300 mm above atmospheric pressure. The DL8 container is mounted in the main bath and this liquid has a vapor pressure of approximately 300 mm at 105 C. When using the DL8, it is necessary to operate the column at reduced pressure (usually 175 mm) to secure an adequate drive or displacement pressure. A manostat mounted on the right end of the main cabinet is used to maintain 760 mm pressure or 175 mm pressure and could easily be set to other pressures if desired.

The Author

K. H. (Ken) Clough is a chemical engineer with W. H. Curtin Company, Houston, Texas, and has a wide experience with the analysis of gaseous (hydrocarbon and other) mixtures in the industry. A native Texan, he received his BS and MS degrees at the University of Texas in chemical engineering and has been active with his present company for 26 years in the development, testing, etc., of laboratory equipment.

Operation

A sample is admitted to the column either by direct charging or by mercury displacement, as previously stated. The lightest component may or may not start overhead at this time, depending upon the composition. Should it go through the column, it will pass through thermal conductivity cell "G," through the take off tube "H," and into any receiver or receivers that are open to it. All receivers "K," "L," "M," and "N" are evacuated, and usually the sample would be directed to receive "K" by opening valve 11. The recorder pen indicates the thermal conductivity of this component by its position between the 0 and 100 marks on the chart scale; thus it may be said to identify the component. A plummet is affixed to stainless steel wires extending through upper and lower ends of one arm of manometer "0." This plummet is insulated from the wire by a short length of nylon cord and can only complete an electrical circuit to the recorder-drive motor when the plummet is in contact with the mercury in the manometer. Before the gas is permitted to pass from the column "F," the plummet is positioned to the mercury surface. Thus when any gas is passed into a receiver, the pressure of this gas acts on manometer "O" and causes the mercury in the external leg of this manometer to rise and contact the plummet. This closes the circuit to the chart-drive motor that turns the chart as well as a shaft containing two tapered spools "V" and "V'." The wire on which the plummet is mounted is wound clockwise on one spool and counter clockwise on the other. Thus the rotation of the motor winds the wire onto "V' " and pulls the plummet out of the mercury, opening the circuit and stopping the motor. As more gas enters the receiver, the mercury in the manometer rises and the process is repeated. The spools are tapered so that the chart obtained is linear with respect to volume. Thus mol percentages of constituents are directly determined.

At some point, the column will attain equilibrium and no further gas will go over. At this point, valve 1 is opened

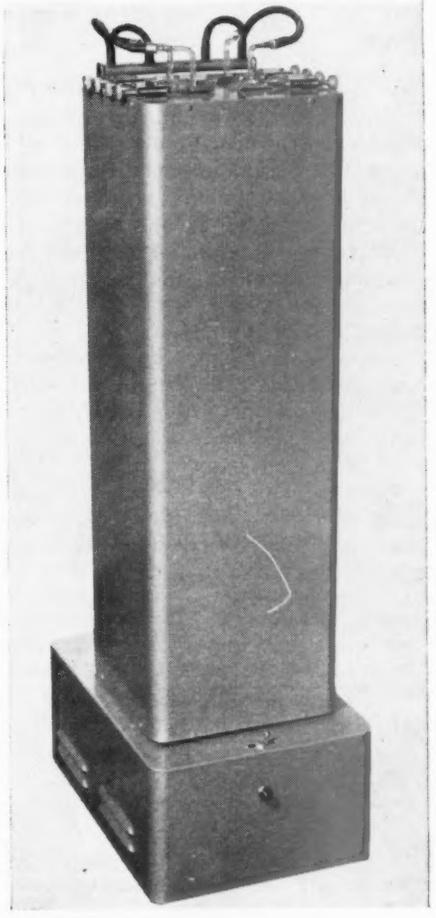

FIG. 3. Back view of desorber unit.

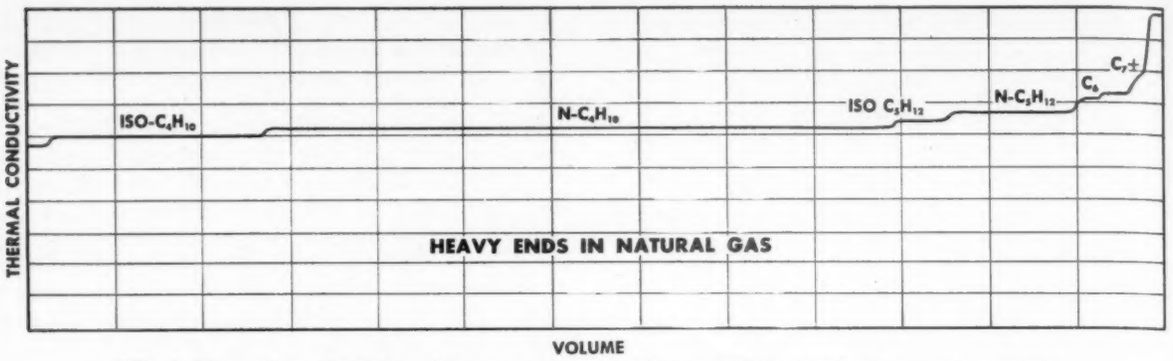

FIG. 4. Thermal conductivity-volume curve for the "heavy ends" of natural gas by analysis.

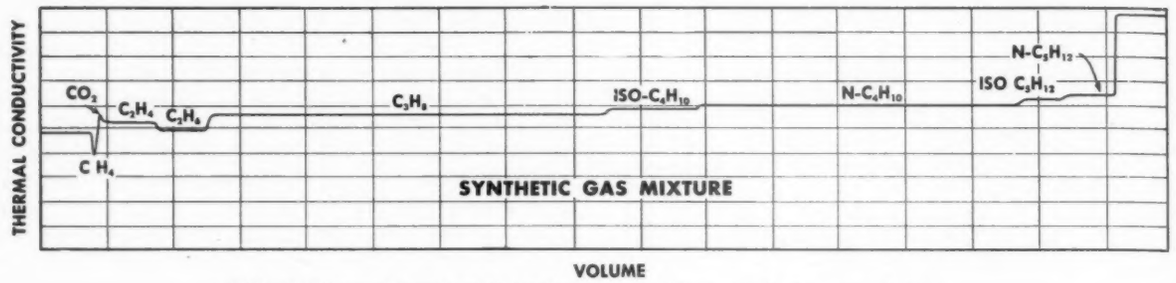

FIG. 5. Thermal conductivity-volume curve for a synthetic gas mixture.

and valve 9 adjusted to allow the vapors from DL5 to drive the gases from the column if the sample contains nothing heavier than pentanes. If the sample does contain heavier components, then valves 7 and 8 are used instead of 1 and 9 and DL8 vapors provide the driving force. Both of these vapors have a thermal conductivity of zero on the scale used, and the sample separation is completed when the displacement vapors reach the thermal conductivity cell and the recorder pen reads zero.

Fig. 4, 5, 6, 7, and 8 represent curves made by the Fracton, and Tables 1, 2, 3, 4, and 5 show typical deviations and analysis time.

Scope and Limitations

Any mixture of organic components that is a gas, or that will be a gas at temperature of 105 C, presents a prospective application for the use of this method of analysis. The complexity of the sample has no effect upon the time required or upon the accuracy. In one instant, eleven separations were made from a mixture of hexanes. Aromatics, olefins, and saturated and unsaturated compounds that fall within the requirements of being in the gas phase under operating conditions should be analyzed.

A second limitation, and an obvious one, is that the sample must not react with mercury. If any part of the sample reacts with mercury, even though the reaction might not be a dangerous one, there would be no possibility of a correct analysis of that sample.

Table 6 shows the relative thermal conductivities of a number of gases, and Table 7 gives the order in which these gases are displaced from the column. From Table 6 it can be seen that propane has a TC of 40.6 and propene at TC of 37.4, but reference to Table 7 shows that they are displaced from the column together. Thus an analysis will show amount of C_3's in sample, but it would be necessary to remove C_3 cut from instrument with the built-in toppler pumps to determine ratio of propane to propene if both were present.

TABLE 1. Heavy ends in natural gas — mol %

Components	Analysis Number 149	150	151	152	Average Analysis	Average Deviation
Iso-Butane	.55	.56	.57	.57	.56	.008
N-Butane	1.66	1.67	1.70	1.68	1.68	.015
Iso-Pentane	.18	.19	.20	.19	.19	.008
N-Pentane	.30	.31	.31	.31	.31	.005
C_6	.12	.13	.13	.13	.13	.003
C_7+	.03	.03	.02	.03	.03	.003
Total C_5+	.63	.66	.66	.66	.66	
Sample Size	9600 ml.	9500 ml.	9700 ml.	9600 ml.		
Analysis Time	3 hrs.	3¼ hrs.	3 hrs.	3 hrs.		

TABLE 2. Synthetic mixture — mol %

Components	Analysis Number 359	360	361	362	Average Analysis	Average Deviation
Methane	.28	.27	.28	.29	.28	.005
Carbon Dioxide	.29	.25	.28	.34	.29	.025
Ethene	4.87	4.91	4.99	4.88	4.91	.038
Ethane	7.22	7.21	7.21	7.25	7.22	.013
Propane	39.96	39.94	39.81	39.78	39.87	.078
Iso-Butane	5.86	5.85	5.78	5.83	5.83	.025
N-Butane	32.93	32.96	33.10	33.02	33.00	.058
Iso-Pentane	4.70	4.64	4.61	4.61	4.64	.030
N-Pentane	3.89	3.97	3.94	4.00	3.96	.035
Total	100.00	100.00	10.00	100.00	100.00	
Sample Size	350 ml.	350 ml.	350 ml.	350 ml.		
Analysis Time	1⅓ hrs.	1¾ hrs.	1½ hrs.	1¾ hrs.	1⅔ hrs.	

TABLE 3. 60/40 propane-butane — mol %

Components	Analysis Number 338	339	341	343	Average Analysis	Average Deviation
Ethane	2.54	2.51	2.48	2.44	2.49	03
Propane	52.17	52.00	52.00	52.04	52.05	.06
Iso-Butane	3.20	3.15	3.19	3.23	3.19	.02
N-Butane	42.09	42.34	42.33	42.29	42.27	.08
Total	100.00	100.00	100.00	100.00	100.00	
Sample Size	350 ml.	350 ml.	350 ml.	350 ml.		
Analysis Time	1¼ hrs.	1¼ hrs.	1⅓ hrs.	1½ hrs.		

TABLE 4. Rapid analysis 60/40 propane-butane — mol %

Components	Analysis Number 342	344	Average
Ethane	2.34	2.44	2.39
Propane	52.46	52.04	52.25
Iso-Butane	2.94	3.23	3.09
N-Butane	42.26	42.29	42.27
Total	100.00	100.00	100.00
Sample Size	110 ml.	110 ml.	
Analysis Time	25-min.	20-min.	

TABLE 5. 26# natural gasoline — mol %

Components	Analysis Number 91	92	93	Average Analysis	Average Deviation
Iso-Butane	2.53	2.44	2.48	2.48	.03
N-Butane	36.88	36.94	36.77	36.86	.06
Iso-Pentane	22.24	22.32	22.24	22.27	.04
N-Pentane	18.47	18.70	18.64	18.60	.12
C_6	14.48	14.36	14.41	14.42	.05
C_7+	5.40	5.24	5.46	5.37	.08
Total	100.00	100.00	100.00	100.00	
Sample Size—(liquid)	1 ml.	1 ml.	1 ml.		
Analysis Time	1½ hrs.	1½ hrs.	1½ hrs.		

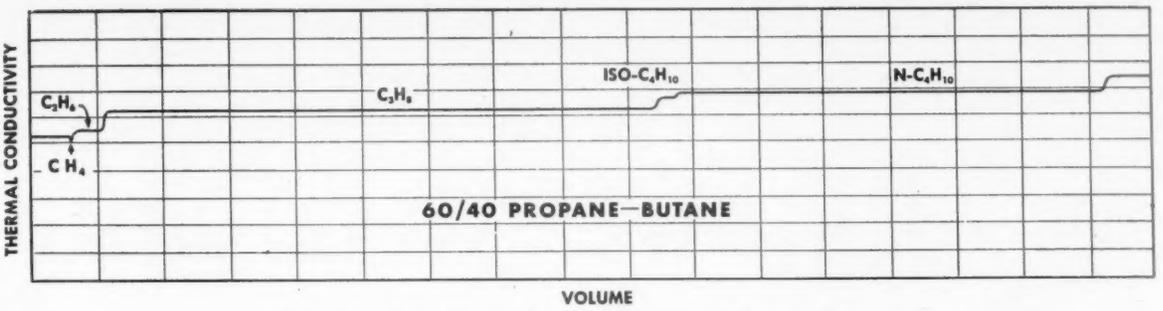

FIG. 6. Analysis curve of a 60/40 propane-butane mixture.

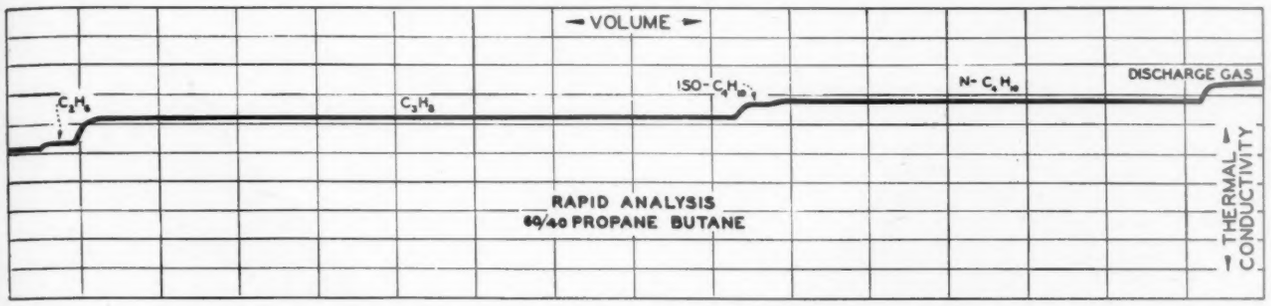

FIG. 7. Rapid analysis curve of the same type 60/40 propane-butane mixture.

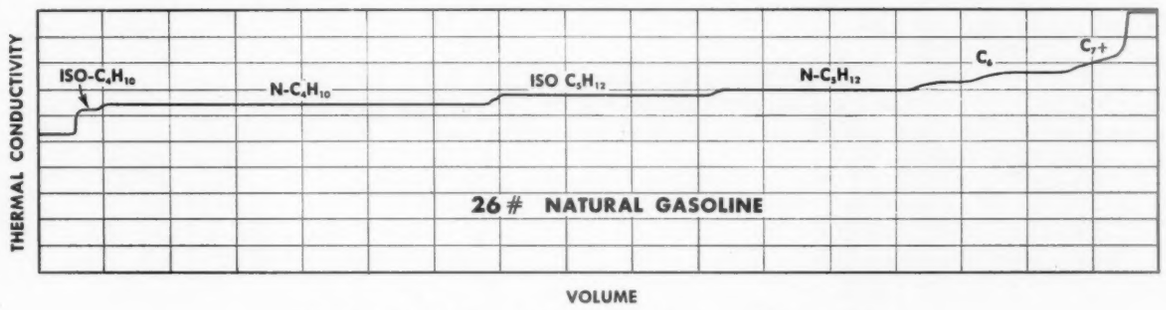

FIG. 8. Analysis curve of a 26-lb natural gasoline sample.

It may also be noted that hydrogen, carbon monoxide, nitrogen, and oxygen would all be displaced together. If a sample contained all of these and it was necessary that the amount of each be determined, it would again be necessary to resort to external means. Thus the Fracton could be used to make group separations or "cuts" to be analyzed by other applicable methods.

TABLE 6. Thermal conductivity Table

Hydrogen	95
Neon	71.8
Methane	63.5
Nitrogen	50
Ethane	48
Ethene	45.8
Propane	40.5
Propene	47.2
Iso-Butane	36.3
Iso-Butene	35.4
n-Butane	34.8
1-Butene	32.1
Isopentane	31.8
1, 3-Butadiene	31
Carbon Dioxide	30.5
n-Pentane	30
2-Butene	28.8
n-Hexane	23.5
n-Heptane	16
n-Octane	10
DL5	0
DL8	0

TABLE 7. Order of displacement from charcoal

Neon
Hydrogen, carbon monoxide, nitrogen, oxygen
Methane
Carbon dioxide
Acetylene
Ethene
Ethane
Propene, propane
Isobutane
n-Butane, 1-butene, isobutene
2-Butene, butadiene
Isopentane
n-Pentane
Hexane
Heptane
Octane

Summary

The selective adsorption and desorption of gases by charcoal and the subsequent identification by thermal conductivity is an important analytical method. Used directly, it is in itself applicable to the large majority of determinations. Its speed and accuracy are very great and the simplicity of operation permits its use by unskilled personnel. There are no involved calculations required. In those few cases where all information desired cannot be obtained by direct means, the Fracton presents a quick method of separation into groups so the remaining information can be quickly secured.

A more recent development, involving the use of a smaller column, a smaller receiver, smaller sample, and a faster chart speed permits an even faster analysis for control purposes to be made. Less than five minutes is required to change glass ware and recorder gears, and this "Quickie" determination can be made. Time required is from twenty to thirty minutes instead of a normal one to two hours. Fig. 7 and Table 4 show results obtained by the "quickie" method. Thus developments proceed to give today's chemists another tool to allow them to solve tomorrow's problems.

Bibliography

1. Guild, L. V., Symposium on Methods of Testing for Liquid Petroleum Gases. September 27-28, 1954.

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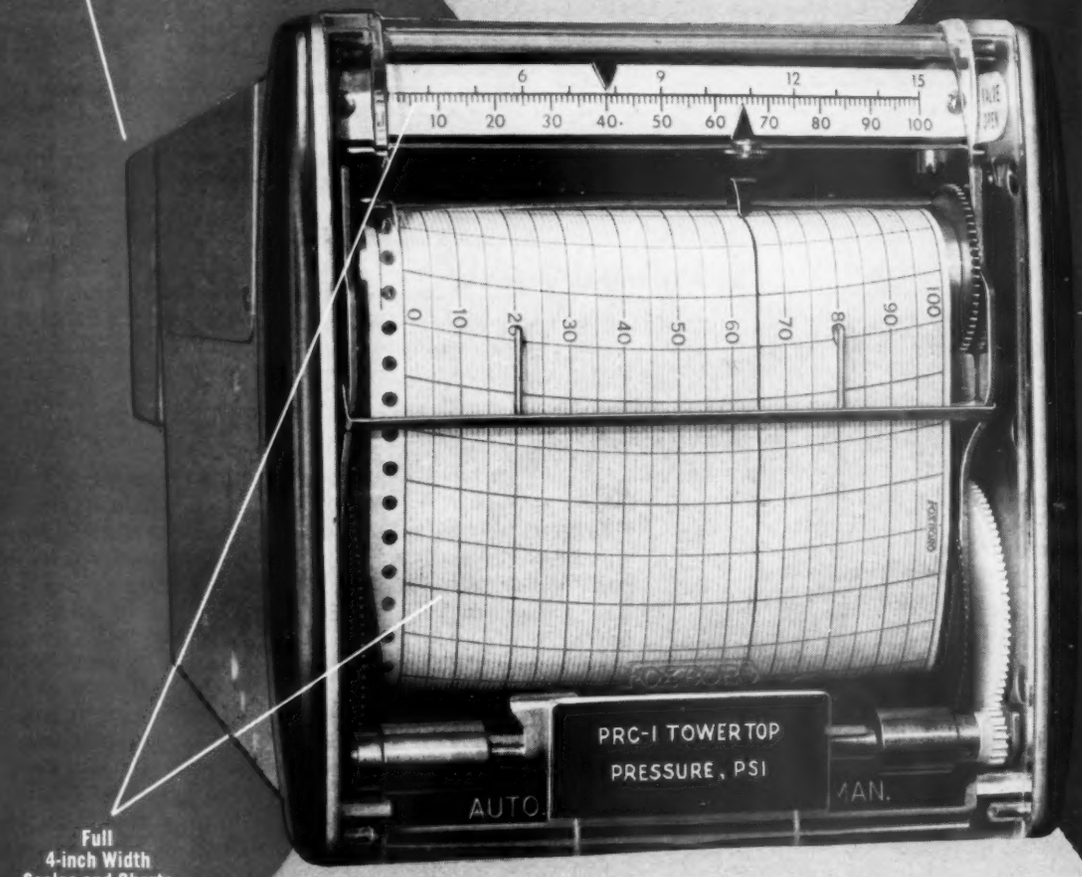

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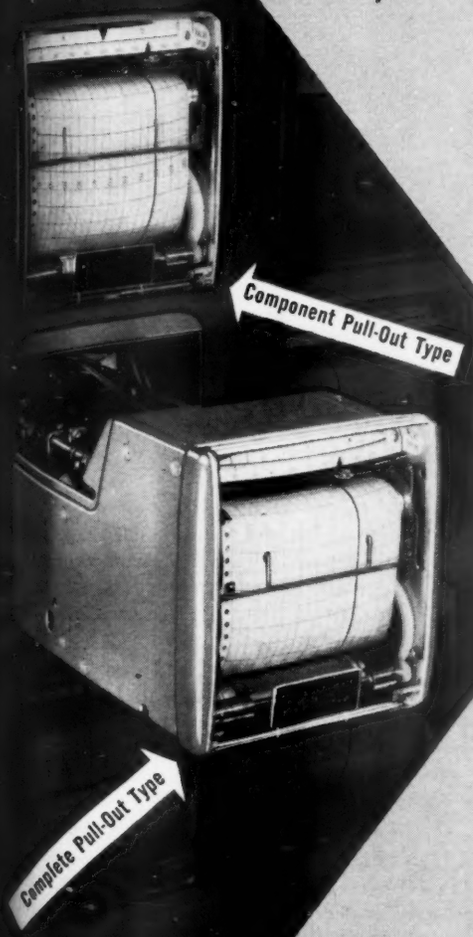

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An Economic Analysis of Water Treatment

M. C. Forbes
Aquatrol, Inc.

BY using the methods described here, the problems to be faced in an economic analysis of water treatment can be clearly defined, the results of using a treatment of less than maximum effectiveness can be evaluated, and rough estimates of the chemical and equipment costs can be made. This will reduce the cases selected for detailed study to a minimum. By carefully selecting the best possible treatment for the water in a plant, savings may be made that far overshadow the actual cost of the treatment itself, with consequent increases in the operating profit of the plant.

Despite many efforts to find a substitute, it is still true that water is necessary in a gasoline plant if the most economical operation is to be obtained. Heat that is added in the processing of the product must be dissipated, and the cooling provided by evaporating water is the best method available. This is especially true for the removal of heat from low-temperature streams. While air cooling has proved helpful in cooling high-temperature streams, the excessive cost of equipment for low-level heat removal by air still leaves a large advantage in the favor of water for this use. Many attempts have been made to reduce markedly the water usage in plants in arid areas, where water is scarce. A glance at Fig. 1 will show why efforts in this direction are necessarily limited. From the graph, it is obvious that if a cooling tower is concentrating the make-up water only two times, 44.5 per cent of the make-up water required at two concentrations could be saved by adopting a water treatment that would allow the water to be concentrated ten times. The problems of scale and corrosion control, however, increase greatly at these high concentrations. By concentrating the water only five times, the problems brought on by high concentration of dissolved salts are halved and the water saving is nearly 85 per cent as great as that at ten concentrations.

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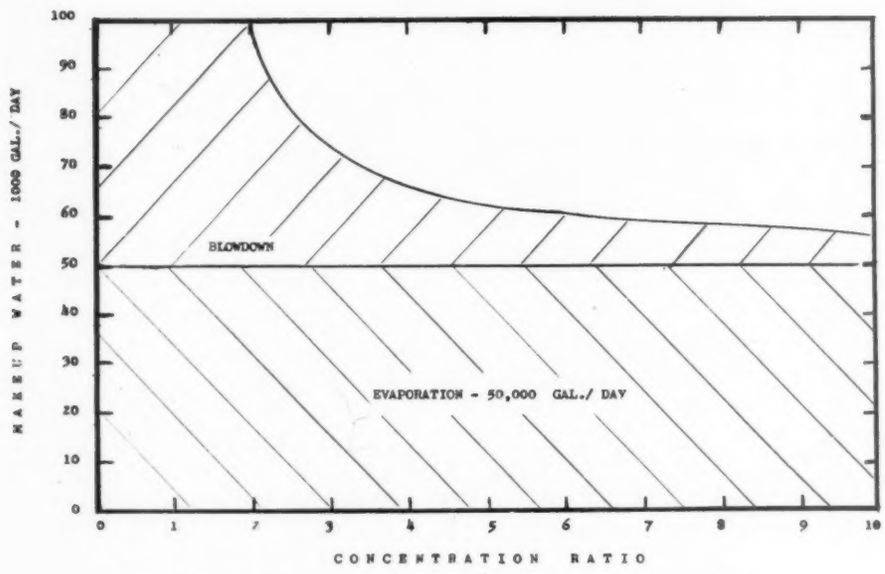

FIG. 1. Make-up versus concentration ratio, in water treating.

The losses caused by the use of water do not usually arise from the water itself but from the materials dissolved in it. Water is an excellent solvent, and water found in nature usually contains an equilibrium concentration of salts and gases that are characteristic of the environment from which the water came. These materials act as food for microbiological organisms giving rise to fouling of equipment by algae and slime growths. They precipitate in the heat exchange equipment and form heat-impeding deposits of scale. They also serve as electrical conductors, allowing the formation of electrolytic cells that cause the equipment to corrode. Water treatment is concerned with the removal of these troublesome substances or the supression of their undesirable effects.

The largest economic losses caused by ineffective water treatment are usually associated with unnecessary or prolonged shutdowns for cleaning and repair. These non-productive periods are expensive because of the loss of profits on saleable products, the cost of cleaning and repair, and the damage that results from the frequent cleaning of the equipment. Perhaps the next largest source of loss lies in the damage to equipment by corrosion, which shortens its life. Equipment that is designed with large fouling factors gives rise to unnecessarily large capital costs that are another type of loss that must be laid at the door of uncontrolled water. Loss in heat-transfer efficiency can cause large increases in the cost of operation of cooling water pumps or compressors. If the lowering of heat transfer gets to the point of reducing throughput in order to prevent high

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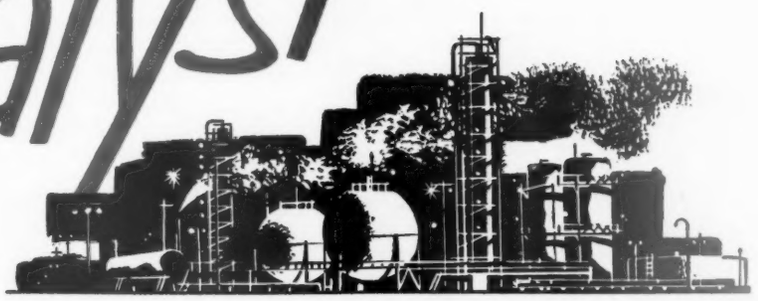

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reflux drum pressures or large vent losses, sacrifice of saleable products again becomes a factor. While it is true that these conditions do not all occur in the average well-run plant, it is the province of the economic evaluation of water treatment to recognize them and seek the best method of preventing them.

A Typical Example

To be more specific, let's examine the magnitude of the savings possible in a typical gasoline plant as compared to the cost of water treatment in that plant. The ratios derived should then be applicable to plants of widely varying size and type with some degree of precision.

For example, if we assume a gasoline plant, costing about $6,000,000, processes about 30,000,000 cu ft per day of gas with a liquid yield of 150,000 gal per day of liquid product, the incremental value of the gasoline and LPG should run in the neighborhood of $8500 per day. With a capital cost of $2000 per day and an operating cost of $2500 per day, the operating profit before taxes would be about $4000 per day or the net profit after taxes would run about $2000 per day. A plant of this type would have a cooling water circulating rate of approximately 6000 gpm, and its water system could cost nearly $200,000. If we assume that the circulating water has a 20 F temperature drop through the cooling tower and the make-up water is concentrated five times, the daily water treatment cost at five cents per 1000 gal of make-up water would be $10.00 per day. A single day's production that could be saved by avoiding or shortening a shutdown would yield a dollar saving of $4000 ($2000 capital cost plus $2000 profit that would not otherwise be made). This would be enough to pay for more than a year's water treatment. The daily capital cost of the water system is about $70.00 on a ten-year basis of approximately $140.00 on a five-year basis. A really effective water treatment could save nearly five times its cost in prolonging the average life of the water system from five to ten years. A reduction in plant throughput of only one per cent due to lowered heat exchange could cost $20.00 per day, and a water treatment that would prevent this would be worth twice its daily cost. Since the cost of pumping the circulating water is roughly ten times the cost of the water treatment, any method of operation that would reduce pumping costs ten per cent by preventing exchanger fouling would pay for itself with the saving realized. Since the maintenance of the water system costs approximately the same as the water treatment, any treatment that would reduce maintenance 50 per cent could save one half its cost. While the ratios derived from this example will not hold precisely for all types of plants, they do indicate the order of magnitude of savings that can be realized from using good water treatment.

Specific Problem

Before savings, such as those quoted, can be realized, the cause of the troubles must be clearly understood and the conditions necessary for their elimination must be known. The specific problems to be faced in cooling water treatment are those of microbiological control (slime and algae), scale control, and corrosion control. These problems ordinarily must be approached in the order given, for corrosion control will not be completely effective if the inhibitor cannot get to the metal surface and scale control is difficult if large quantities of slime or algae are present.

Microbiological growths are one of the worst troublemakers in a water system and they present the most difficult control problem. These masses of living matter can reduce cooling by impeding the flow of water by their actual physical bulk; they can interfere with the flow of heat themselves, and they cause other debris to collect, which aggravates the situation. The gelatinous nature of most of these growths forms a very effective semi-permeable membrane that is very effective at causing corrosion by forming oxygen concentration cells. The same membrane that causes the corrosion also prevents any corrosion inhibitor from reaching the metal where it is needed.

Microbiological control still is quite empirical since organisms of apparently the same strain do not react to the same toxic agent under different conditions or even under apparently the same conditions at different times. The most reliable standard for controlling these growths is visual inspection.

The precipitation of insoluble materials from the water onto the heat-transfer surfaces is ordinarily thought of as a heat-transfer problem. While this is true, the restriction of the flow of cooling water and the role of scale in corrosion are problems that must not be overlooked.

Scale control is aimed at the elimination of deposits on heat-exchange surfaces by the elimination or control of materials that would precipitate out of the cooling water. The worst offenders in this line usually are calcium carbonate, calcium sulfate, silica-iron oxide, and calcium phosphate. Calcium carbonate scale may be prevented by maintaining a suitable stability index in the circulating water by blowdown control, by softening the make-up water, and by using sulfuric acid for alkalinity and pH control. The glassy phosphates and colloidal organic materials added to the water are also used. The stability index is basically a modified solubility product for calcium carbonate, as derived by Langelier and modified by Ryznar. It may be calculated with sufficient accuracy for most work from the relation S.I. = 22.70-2 (log Ca + log Alk)-pH_0 where the calcium and alkalinity are expressed in ppm as $CaCO_3$ and pH_0 is the pH actually observed in the water system. This assumes a film temperature of the water on the exchanger tubes of 140 F and a total solids of 2000 ppm or greater. Without the phosphates, the stability index should be kept above 5.5, and with them it may be carried at 4.0 or more. Calcium-sulfate scale is prevented by the use of softened make-up water or blowdown control in such a manner that the product of the calcium ions (ppm as Ca) and the sulfate ions (ppm as SO_4) in the circulating water is kept below 500,000. Silica scale is prevented by blowdown control to keep the theoretical silica (ppm SiO_2 in the make-up X the concentration ratio) below 200. Iron-oxide scale is prevented by removing the iron from the make-up water to a level of 0.3 ppm or lower. Calcium-phosphate scale is controlled by external softening, blow-down, and acid control similar to the stability index for calcium carbonate.

Corrosion in most water systems is the result of electrolytic cells that depend on oxygen in the water for cathodic depolarization. Oxygen removal for corrosion control has been used in some cases with notable success. In all cases, large quantities of oxygen are dissolved in the water each time it circulates over the cooling tower so that deaeration, either chemically or mechanically, is normally too expensive to be competitive with other methods of corrosion control. The best method of corrosion prevention usually is based on the addition of a corrosion inhibitor containing hexavalent chromium to the circulating water. When the chromium is used as the sole method of corrosion control, quite large amounts (approximately 500 ppm) are required. This can cause a pollution problem if the cooling tower slowdown flows into a public water course.

Much lower concentrations of chromium can be used if it is used in conjunction with phosphates or more preferably zinc. Several other types of corrosion-control agents are available such as the straight phosphates or the phosphate-silica mixtures, but in general these have proved to be less effective.

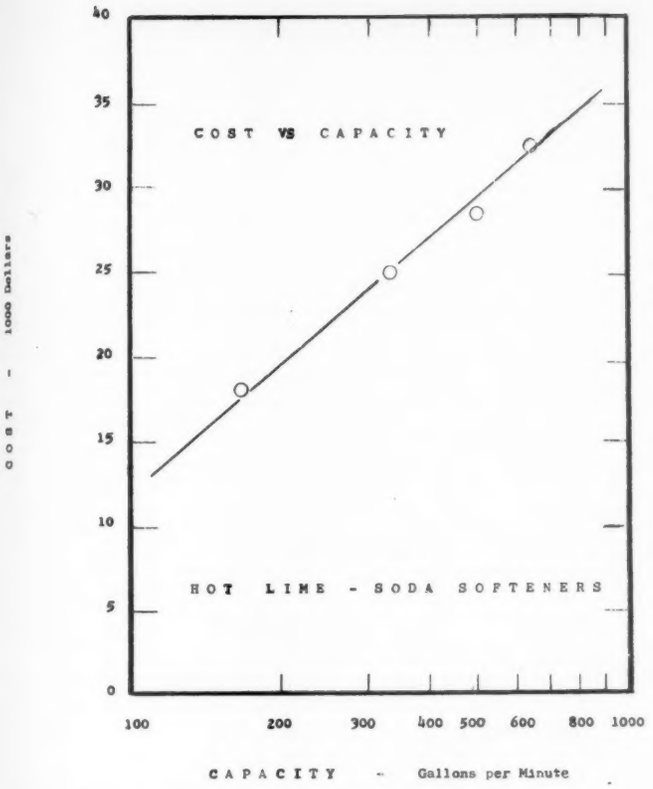

FIG. 2. Comparative costs vs hot lime-soda softening.

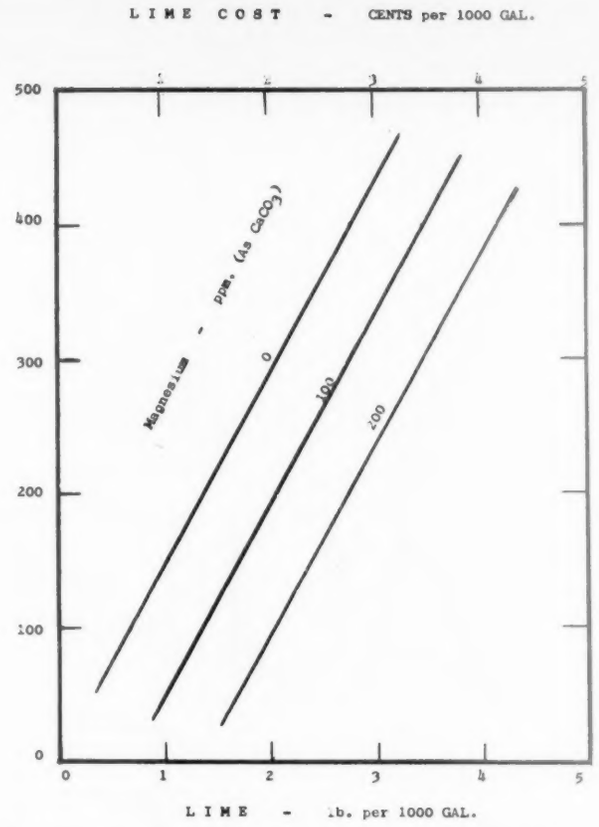

FIG. 3. Lime cost as compared to alkalinity and magnesium.

Boilers suffer from the problems of scale and corrosion much as other systems do, but microbiological growths are not a problem because of the high temperature involved. Boilers have other problems not common in cooling towers, however, for difficulties with foam, condensate corrosion, and embrittlement must be considered in boiler water treatment. Scale and foaming are often attacked by a combination of external treatment for oil removal and softening combined with internal treatment (usually a phosphate) to precipitate any residual hardness in the form of a non-adherent sludge plus the use of some proprietary antifoam-compound. Organic materials such as tannins, vegetable gums, and lignin derivatives are used with the phosphates to aid in preventing the formation of an adherent sludge. Embrittlement is combatted by the use of nitrates, organic inhibitors, and proprietary mixtures designed to eliminate this problem. Corrosion is prevented by external deaeration by stripping with steam under low pressure plus internal treatment with a reducing agent such as sodium sulfite or hydrazine, and the control of alkalinity by blowdown control with the addition of alkaline materials when necessary. The boiler water should show no residual hardness and the alkalinity should be maintained between 400 to 600 ppm as $CaCO_3$ if possible. Actual industrial practice embraces the range of 250 to 1000 ppm.

Engine-jacket systems are usually fed with softened water or condensate to prevent scale, and corrosion is controlled with a high concentration of a material containing hexavalent chromium. Since there is little make-up or blowdown associated with units of this type, the problems of cost or of pollution are not great.

External or Internal Treatment?

The question is often asked "Shall we treat the water externally to remove the ions causing the trouble, or shall we add chemicals to the water in the system to prevent their bad effects?" This is a question that cannot be answered honestly without an economic analysis of the situation. There certainly are many conditions where neither type of treatment alone can do the job satisfactorily, but a combination of both is required. In other cases where it is technically possible to use one or the other, the optimum treatment can be chosen only after careful study.

Cost of Chemicals and Equipment

While detailed cost studies based on actual quotations of the chemicals and equipment delivered to the plant site are necessary for a final decision, preliminary estimates should be used to reduce the final cases chosen for detailed study to a minimum. The figures given were taken from actual quotations and represent good industrial practice. Because of the wide variation of designs and locations of the installations, the ranges given are necessarily broad, and in some cases values outside these ranges will be found. The median values, however, represent a practical approach to cost estimation for rough evaluation of costs.

Mechanical Treatment

Aeration, deaeration, sedimentation, and filtration are usually thought of as mechanical processes that require little chemical treatment in their operation. Aeration is carried out most frequently in forced-draft aerators similar in construction to small forced-draft cooling towers. The equipment will cost from $5 to $25 gpm of capacity with an average cost of about $10 gpm. The operating cost is low since it is limited to power for operating the fan and any auxiliary pumps that may be required. For the removal of acid gases, such as CO_2 and H_2S, pH adjustment with sulfuric acid is required.

Coarse suspended solids may be removed by retaining the water in reservoirs or settling basins. Earthen reservoirs will cost from $175 to $300 per acre-ft of capacity. Finer suspended solids are removed by filters (with or without a filter aid) using sand or anthracite coal as the filter media. In

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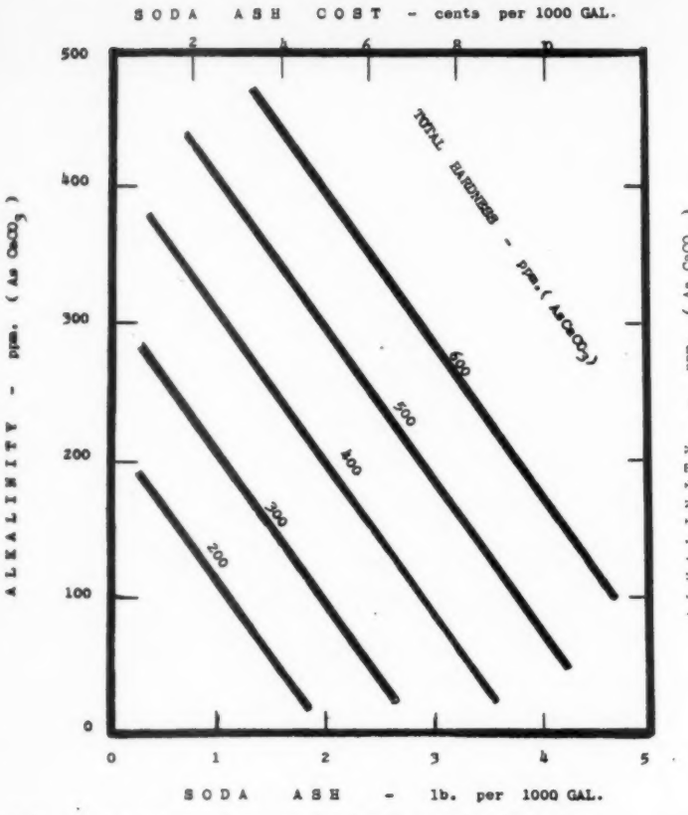


FIG. 4. Soda ash requirements for hot lime-soda softening.

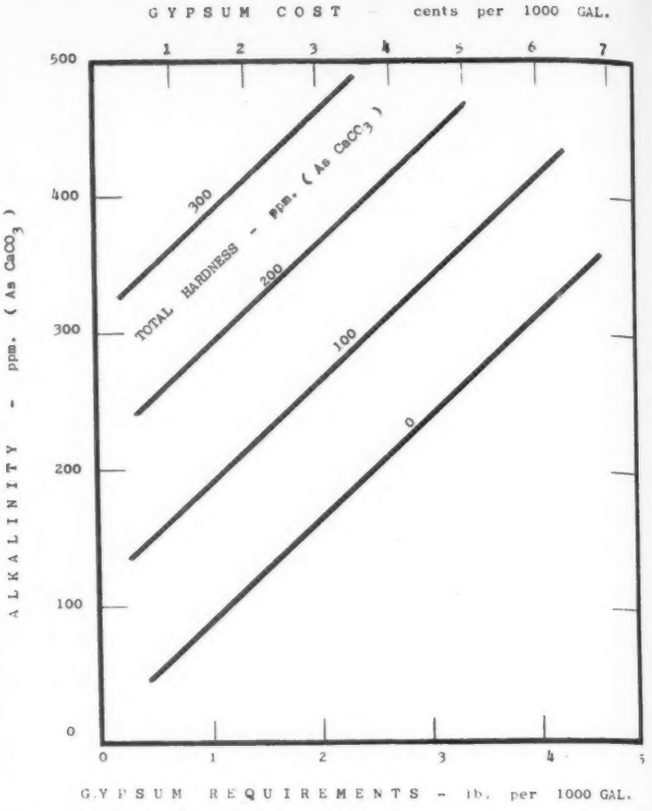


FIG. 5. Amounts of gypsum required in hot lime-soda softening.

most plants, pressure filters are used. They cost from $20 to $75 gpm of capacity with an average cost of about $35 gpm. Oil removal is very closely allied to filtration because it is accomplished by feeding a floculating agent such as alum to the water to adsorb the oil and then removing the floc on a filter. Another method of oil removal involves the passage of hot oily condensate through a conventional anthracite filter that serves not as a filter but as a coalescer. The large drops of oil that are formed by the coalescer may then be removed in the conventional skimming tank.

Chemical Treatment

Clarification is frequently carried out in conjunction with softening, but when the process is carried out alone, the equipment will cost in the neighborhood of $100 gpm of throughput.

Softening may be carried out by direct reaction with lime and soda ash (or gypsum) either hot or cold, or it may be accomplished by ion exchange. In ion exchange, the calcium and magnesium ions causing the hardness are most often exchanged for an equivalent quantity of sodium ions. If alkalinity reduction is also desired, they are exchanged for hydrogen ions. Hot lime-soda softeners cost from $60 to $120 for each gallon per minute of capacity with an average value of $100 gpm. Fig. 2 shows a plot of the actual cost of a wide range of hot lime-soda softeners quoted by one equipment maker in 1953 and 1954. When the alkalinity of the water exceeds its hardness by 25 to 50 ppm, lime is the only reagent required. The lime dosage and cost may be estimated from Fig. 3 (lime at $20 per ton). When the hardness is equal to or greater than the alkalinity, soda ash must be added to balance the softening reaction. The quantity and cost of the soda ash may be estimated from Fig. 4 (soda ash at two and five-tenths cents per pound). Where the alkalinity is greater than the hardness by more than 50 ppm, some calcium salt (usually gypsum) is added. The gypsum requirements may be calculated from Fig. 5 (based on gypsum at one and five-tenth cents per pound).

Softening through ion exchange is carried out by passing the water over a chemically treated synthetic resin that trades sodium or hydrogen ions for the calcium and magnesium ions in the water. The equipment is very similar to filtration equipment except it has provision for the addition of chemicals to regenerate the resin. The units used for sodium exchange cost from $10 to $20 for each pound of hardness (expressed as ppm $CaCO_3$) that is removed from the water in one cycle, Fig. 6. Fig. 7 shows the chemical cost assuming salt at one cent per pound. The units used in hydrogen exchange are somewhat more expensive because they must resist corrosion by the acid used in regeneration and by the acid water flowing from the units. Hydrogen-exchange, zeolite softeners cost from $15 to $40 per pound of total cations removed in one cycle. Fig. 8 shows the cost of hydrogen zeolite units as a function of the throughput and the concentration of the ions removed (expressed as ppm $CaCO_3$). Fig. 9 shows the chemical cost of operating a hydrogen zeolite unit assuming sulfuric acid at two cents per pound. In preparing these charts, it was assumed that two exchangers of eight hours' capacity each are provided so that one may be regenerated while the other is in service.

Where water of exceptional purity is required, hydrogen-zeolite ion exchange may be used to substitute hydrogen for all the cations and then the water passed over a different type of resin where all of the anions (such as sulfate, chloride, phosphate, etc.) are exchanged for an equivalent quantity of carbonate or hydroxyl ions. The resulting water then has all of the properties of high purity distilled water. Total deionization is not often used in petroleum processing plants except for make-up to engine jackets and occasionally to process feedwater for high capacity boilers.

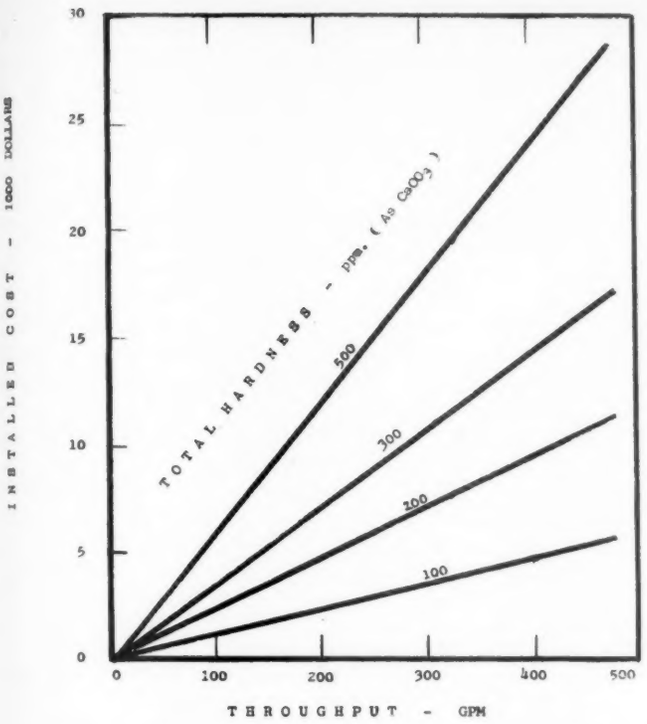


FIG. 6. The installed cost of sodium zeolite softener untis.

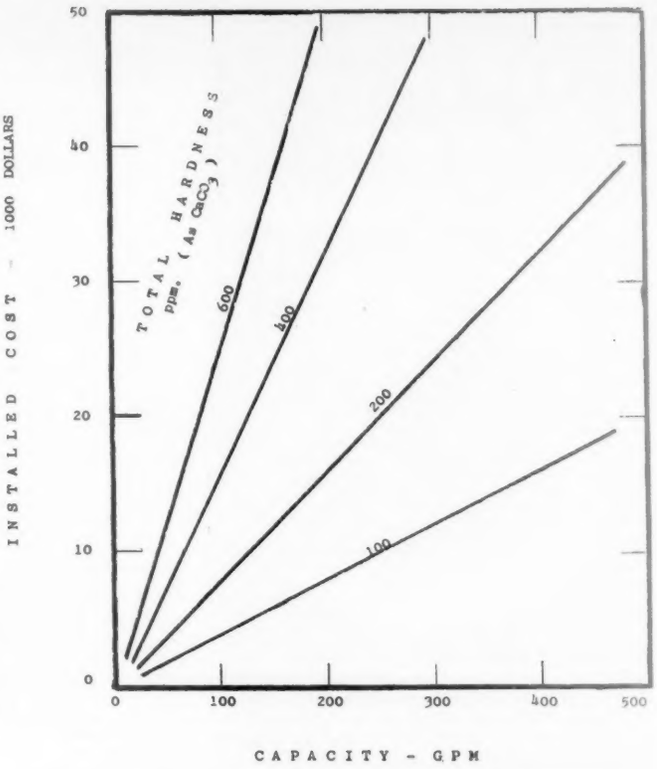


FIG. 8. Costs of installation of hydrogen zeolite softeners.

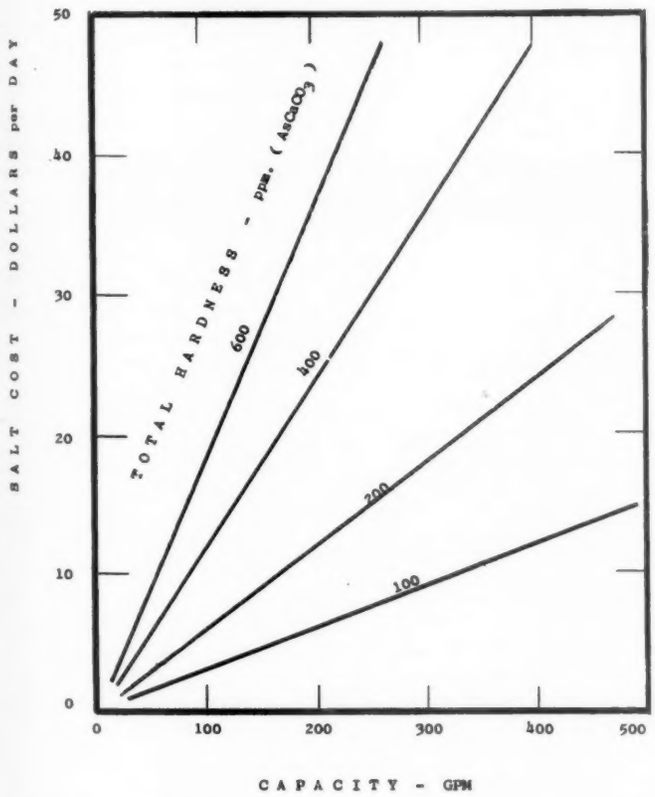


FIG. 7. The cost of salt consumed in sodium zeolite softeners.

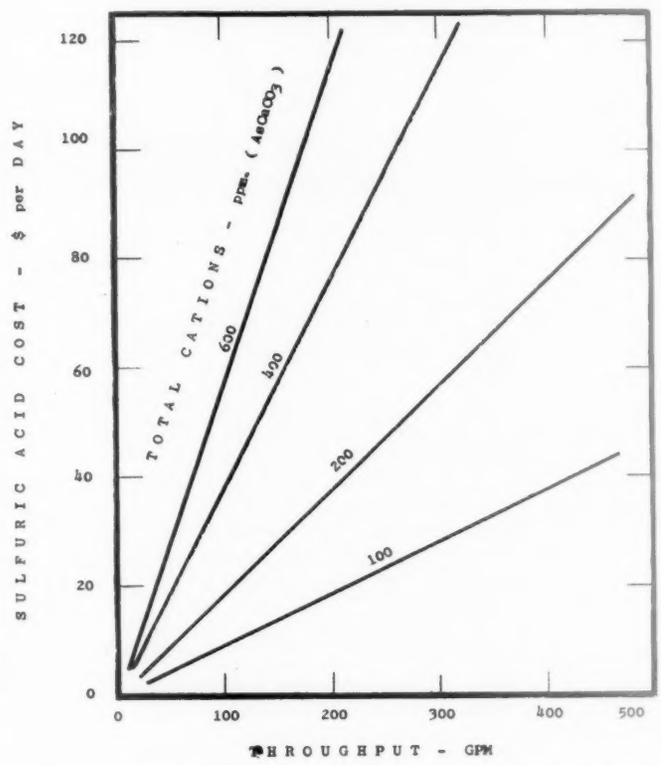


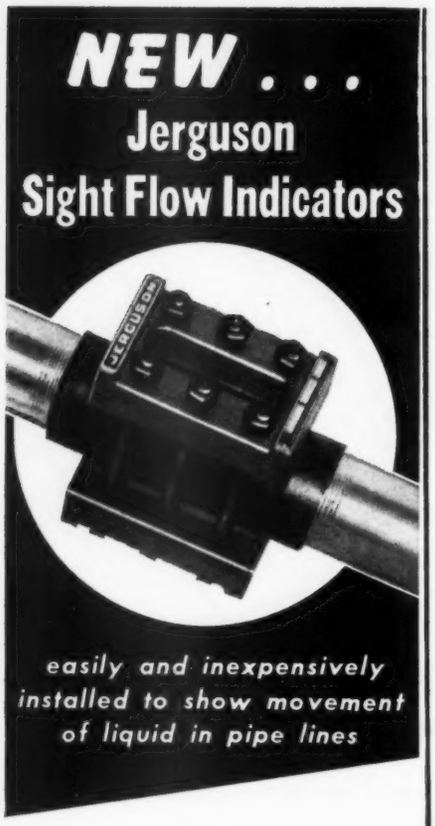
FIG. 9. Costs of sulfuric acid for hydrogen zeolite softeners.

Internal Treatment

It is difficult to give useful ranges for estimating the cost of internal water treatment because water composition and operating vary so widely. There also is no common cost basis for the chemicals used since the majority of plants use proprietary chemicals for internal treatment.

The cost of algaecides, other than chlorine, is usually based on the quantity of water in the system. The largest factor controlling the cost of scale and corrosion inhibitors is the maximum allowable concentration ratio. The cost of acid for alkalinity and pH control is based primarily on the alkalinity of the make-up water.

Most plants spend from 5 to 15 cents per gal of make-up water for internal treatment, including the cost



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of acid and algaecide. The average cost would be 10 cents per 1000 gal of make-up water or less.

Boiler water presents similar problems in estimating the cost of internal treatment though the factors causing the variation are somewhat different. The largest single factor in boiler-treatment cost is the hardness of the make-up water. The cost of chemicals for internal treatment of boilers should run from 5 to 30 cents per 1000 gal of raw or treated make-up for each 100 ppm of hardness present in the water. The average cost would probably lie at 20 cents per 1000 gal of make-up per 100 ppm of hardness.

Algae and slime growths are controlled by adding toxic materials to the water that interfere with the metabolic processes of the microorganisms. The toxic materials used may be classed in several groups based on their chemical structure. The substances most often used are the halogens (chlorine and bromine), the heavy metals (salts of copper, mercury, and arsenic), the chlorinated phenols, and the quaternary ammonium compounds.

The halogens are used in concentrations of 0.5 to 5.0 ppm but care must be used to see that delignification of cooling-tower wood does not take place.

The heavy metals may be used in concentrations of 0.5-50 ppm of the active metal ion, and some provision is normally made to add stabilizing agents to prevent precipitation of the ion before it can act on the organism.

The chlorinated phenols are effective in the range of 5 to 50 ppm, and it has been found that by compounding them with other additives the toxicity to algae can be considerably enhanced.

The quaternary ammonium salts work well in approximately the same concentration ranges as the chlorinated phenols (5 to 50 ppm), but they are made less effective in waters of high hardness or sulfate content. Attempts have been made to formulate a superior slime-control agent by the combination of the chlorinated phenols and the quaternary ammonium salts. Though some success has been reported in this field by other workers, it is known that many compounds of this type are ineffective. Theoretically, such a compound should be less satisfactory since one of the components is anionic and the other cationic, and as such, they should be antagonistic to each other.

Scale prevention must usually be based on carefully selected concentration control plus alkalinity and pH adjustment by acid addition to achieve the desired stability index. The maximum allowable concentration ratio of the system can be considerably increased in some cases by adding scale inhibitors containing organic colloidal materials and one of the so-called "molecularly dehydrated" phosphates. These scale inhibitors are added in sufficient quantity to maintain a residual in the circulating water of 10 to 40 ppm.

Corrosion control by internal treatment is brought about by adding substances that interfere with the action of the electrolytic cells causing the corrosion. Nearly all of these inhibitors act by forming thin films at the electrode surfaces that accomplish their purpose without disturbing the flow of water or heat. Hexavalent chromium salts form mixed chromium-iron oxide films over the anodic areas where the corrosion is taking place. When used improperly, they can actually increase the damage done by corrosion because they reduce the area over which the corrosion is taking place much faster than they reduce the total corrosion rate. This gives rise to the formation of pits in the metal. The chromium concentration may be reduced without danger if a second inhibitor such as phosphate is added or if zinc salts that control the cathode reaction are added. The use of a cathanodic treatment of the zinc-chromium type tends to eliminate the pitting problem. Attempts to control corrosion with deliberately formed deposits of calcium carbonate or calcium phosphate have not been too successful because the rather large, negative temperature coefficients of solubilities of these substances make them difficult to control in a non-isothermal system such as a plant-cooling cycle. Silicates and nitrites have also been used for this purpose, but they are effective only under certain limited conditions.

Conclusion

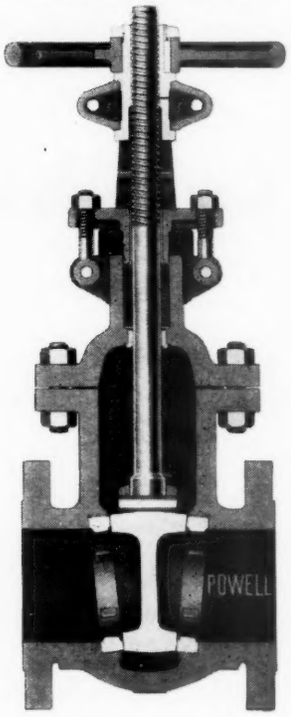
An economic study is made to serve as the basis for action. In order to make the decision on which the action is based sound, there are many questions that must be answered, but it is a rare study that does not leave out some important information because of lack of time, data, or an understanding of the nature of economic analysis. Too often, the unit price or total cost is used as the basis for decision while more important factors are ignored. Decisions on the choice of water treatment are no exception.

An economic analysis should first of all contain a clear statement of the problem, an estimate of the results of solving the problem with less than maximum efficiency, and a study of the effectiveness and cost of the various possible solutions of the problem. When these are all in hand, the basis for a sound decision has been achieved.

* * *

POWELL VALVES ... THE COMPLETE QUALITY LINE ... POWELL VALVES

FIG. 1503 (Sectional)—
150-Pound Steel Gate Valve.



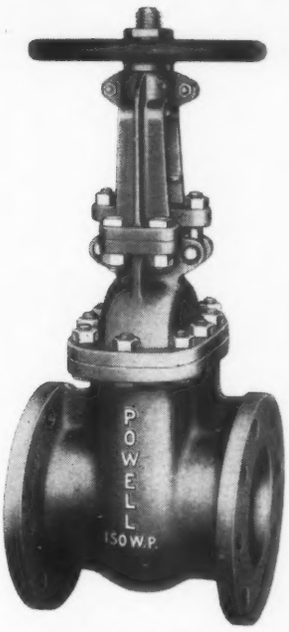
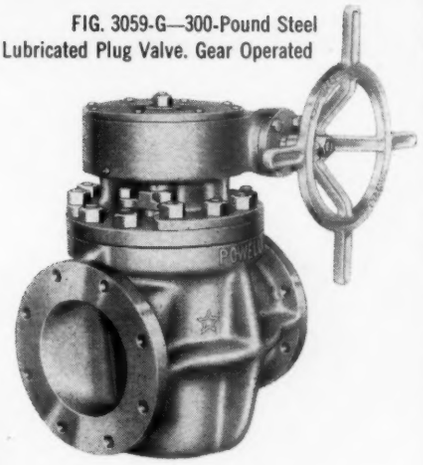


FIG. 2453-G—Stainless
Steel O.S. & Y. Gate Valve
For 150 Pounds.

FIG. 3059-G—300-Pound Steel
Lubricated Plug Valve. Gear Operated



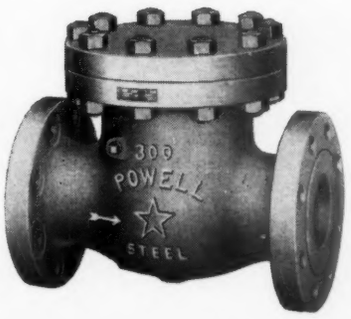


FIG. 3061—300-Pound
Steel Swing Check Valve.

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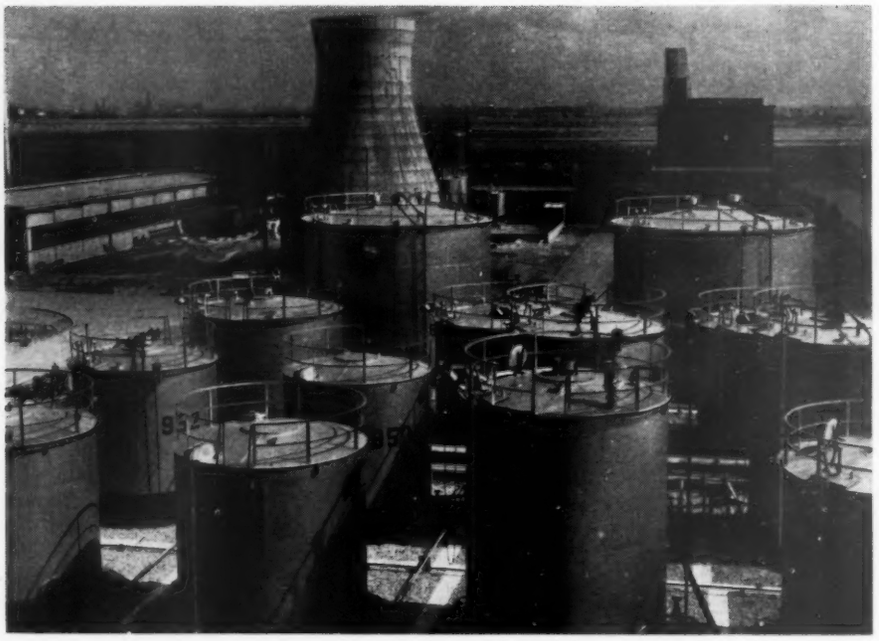
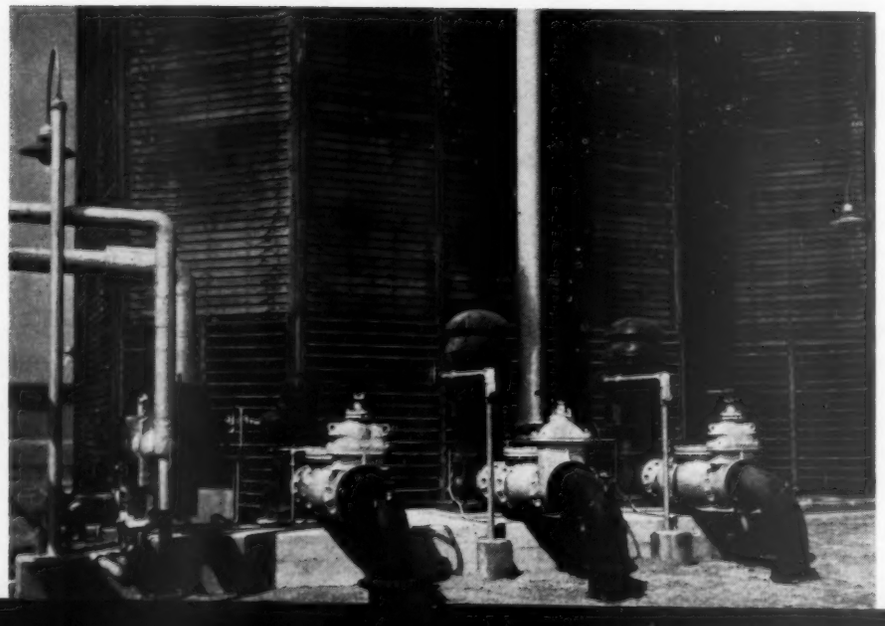
A Survey of Water Conditioning Pro

J. W. Gibson
D. W. Haering & Company Incorporated

This concrete "venturi-type" water cooling tower is typical of English and European design, a far cry from American practice.





Such water cooling towers as this, in the arid southwest U. S. A., may be used also as treating basins to condition boiler and cooling water.

MAXIMUM conservation of available water, and the economics involved in conditioning that water for greatest possible re-use, have become primary considerations, particularly in the water-short areas of the southwestern and western states. Much progress has been made in recent years in processes available for conditioning water to allow maximum re-use within economical limits.

Advances in methods of primary treatment or combinations of such methods make possible more economical or more efficient removal of undesirable ions, which in turn allow much greater concentration of that available water in the water systems. This serves to lower the water requirements as well as to lower the cost of internal after-treatment, both of which represent savings that can pay back, at least in part, the increased cost of the primary treatment.

Increased awareness in recent years on the part of management of the importance of conditioning water is commendable. This attitude has resulted from much constructive educational effort by water consultants, manufacturers of water-using equipment, and independent investigators accelerated by the impetus of water shortage and resultant difficulties. Claims and counter-claims in several areas of the work continue to confuse not only the layman but many technical personnel.

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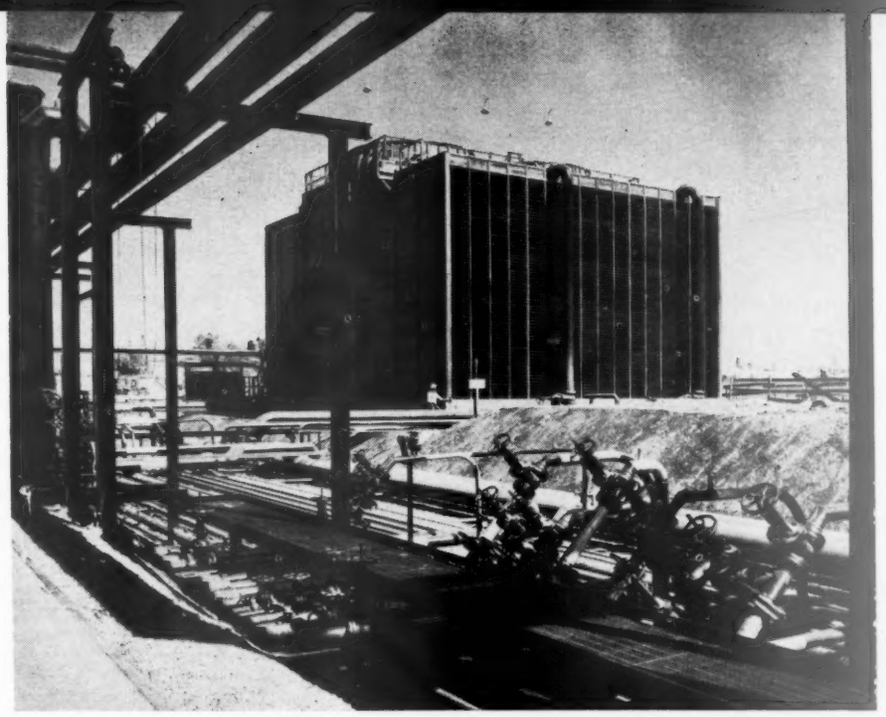

This huge cooling tower is used also for treating "hard" water to soften it to avoid scale deposition in boilers and condenser boxes.

ingpractices

While areas of apparent confusion lie primarily in the deeper realm of the work in regard to the field of internal after-conditioning and the inhibition of corrosion, there is much basic work upon which all workers are in essential agreement.

For management to have an awareness of the need for conditioning but to act in the absence of proper counsel, however, is not wise. For example, new plants continue to be designed without proper consideration being given to the quality of available water and proper methods of conditioning such water for maximum economy of use, both in regard to costs of primary conditioning and internal after-conditioning. In hard water areas, it is generally recognized that softened water is better than hard water, and so a decision may be made to include a water softener in the original installation. Since the sodium cation (sodium zeolite)—type softener has been of high popularity in past years and is simple to operate, then that type unit may be, and generally is, accepted as a routine gesture.

Based on present advancement in the science, such a decision may be unwise. Such a unit will simply soften the water through exchange of calcium and magnesium by sodium and nothing more. It is an easy way to soften water, but not necessarily the cheapest. In some situations, it may accomplish no practical end-result in regard to control and economy, and in other cases it may accelerate difficulties to be encountered under plant operation.

With a sodium-cation exchanger, the exchange of the more aggressive sodium ion in place of calcium and magnesium will accelerate the corrosion potential. Soluble solids are not lowered but are, on a strict weight basis, slightly increased. For boiler use, the conversion of natural alkalinity to the sodium salts will result in a higher release of carbon dioxide gas over into the generated steam for accelerated steam and return line corrosion. For use in cooling tower waters, the sodium alkalinity that would result from concentration of the water and temperature conversion can be extremely detrimental to the cooling tower wood as well as to some of the more noble alloys, particularly those containing copper and aluminum. Correction here would require pH adjustment that could represent a control that might, in itself, have controlled scale formation on hard water make-up without much additional increase in acid consumption. Silica content of the softened water remains unchanged and may place a strict limitation on maximum usage.

External Processes

The sodium-cation exchanger is a valuable tool in conditioning water.

Even in cold climates, cooling-treating towers are needed to make possible the proper conditioning of plant process and boiler water.

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Its use has been greatly increased by the development of exchange media capable of high capacity at wide ranges of temperature and pH that increase its flexibility, particularly for use under combination methods in conjunction with other types of conditioning equipment. The proper selection of such equipment has, therefore, become considerably more complex. A recommendation that water should be softened is no longer valid. Proper selection demands that water quality be considered to provide a finished water that can be utilized to a maximum extent under the particular type of operation in which it is to be employed. The total cost of the program in regard to both primary or external conditioning and internal after-treatment must be considered. Such calculations should preferably be based on the horse power or heat load of requirements of the plant systems rather than on a unit volume of water.

The hot process, precipitation-type softener continues to be one of the most versatile tools available for economic conditioning. Chemical cost for softening is generally cheaper than by ion exchange methods although in some areas operating and maintenance costs may be considered higher. The primary technical gain through the use of the hot-process unit is reduction of solids, particularly alkalinity and silica, which can represent considerable advantage in both control and economy of usage in the operating systems. The advent of deaerating-type, hot-process softeners allows the process a greater economic advantage for boiler use since a separate deaerating heater is no longer required. Advances in sodium-cation exchange media allow passage of the hot high-pH effluent from the precipitation softener to provide a final effluent of "zero" hardness at minimum total alkalinity.

Cold-process precipitation softeners are particularly advantageous where primary concern involves removal of calcium alkalinity to a low level. This process is of particular advantage in conditioning cooling tower make-up where the solubility of calcium sulfate might otherwise impose a strict limitation. Alkalinity reduction is more cheaply accomplished with lime than with acid. The use of a combination cold lime-sodium cation exchange process provides the cheapest method of total softening, and technical advantage is also gained in a lower total alkalinity and a lower silica content.

A hydrogen-cation exchanger for alkalinity removal is finding broader usage, particularly in conjunction with a sodium-cation exchanger where the two effluents can be blended for a predesignated alkalinity control. Major application is for boiler feedwater conditioning where silica is not a limiting factor. Ease of operation and flexibility in alkalinity range desired are major advantages.

A relatively new method of providing alkalinity reduction is dealkalization or "salt splitting." This process involves anion exchange of alkalinity and sulfate by chloride, using sodium chloride as the regenerant. When used in conjunction with a sodium-cation exchanger, the water can be both softened and dealkalized in a convenient installation requiring only one salt tank for both units. Also, both exchange media can be placed in one unit for maximum simplicity. Its simplicity of operation is of particular advantage where unskilled operators are involved. It is more expensive to operate than other methods, but this increased cost may be warranted in many cases. A major disadvantage is the exchange of both alkalinity and sulfate by chloride and the fact that sulfate is removed more efficiently. The exchange of sulfate by chloride generally involves no particular technical advantage in industrial soft waters. Based on $CaCO_3$ equivalents, twice as much salt is required to exchange sulfate as required to exchange chloride so that the sulfate exchange serves only to increase needlessly the cost of the process. Sulfate is exchanged almost entirely so that with a sulfate water this process could become economically unreasonable. The alkalinity exchange ranges from 80 to 90 per cent, leaving a residual alkalinity that is generally desirable.

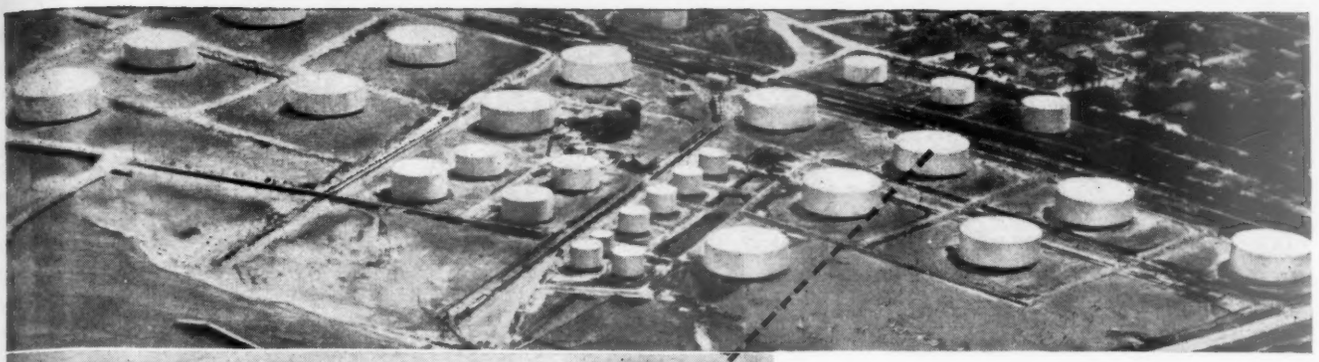
The dealkalization units have been proposed as a means of alkalinity control for cooling tower make-up, and it is a simple method if the expense is warranted. Use in this regard must generally be confined to small systems and to systems having soft or low hardness water. The process has been suggested as a means of replacing the use of sulfuric acid for control of pH of cooling tower waters on hard water make-up. Advantages are its simplicity, inability to inject free mineral acidity to the cooling water, and eliminating the handling of sulfuric acid. Disadvantages are increased chemical cost and the fact that under many conditions, when using hard water, the alkalinity cannot be held low enough for scale control without resorting to increased blowdown rates that increase the costs further. Since an average of 15 per cent of the alkalinity remains following dealkalization, then the effluent alkalinity can continue to be appreciable and impose a strict limitation on water concentration. No operational gain has been made unless the process can completely eliminate internal acid treatment.

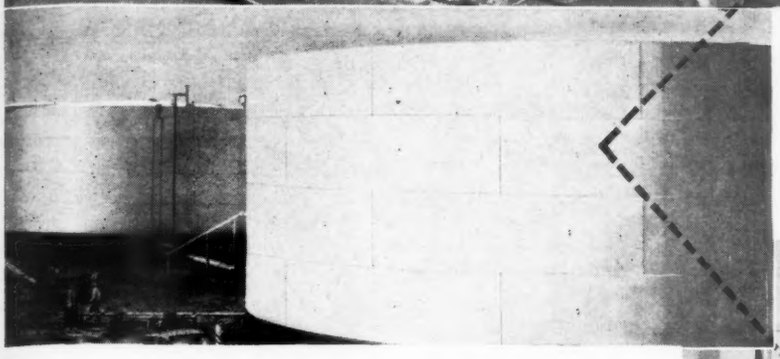
"Salt splitting" has also been used for removal of silica without demineralization. The same strongly basic exchange resins that are used in demineralization following cation exchangers on the hydrogen cycle are also used in salt splitting. These resins cannot only absorb strong and weak acids, but they can split salts or exchange anions for chloride or hydroxyl in the resin. By using caustic soda as the regenerant rather than sodium chloride and using a "zero" soft water as influent, all anions, including silicate, are exchanged for hydroxyl ions. The effluent should usually be neutralized for conversion of sodium hydroxide alkalinity and the influent must be softened, but the process is cheaper than silica removal through demineralization or evaporation. It is more expensive to operate than the hot lime-zeolite process although equipment cost is less. Of interest is pilot plant studies indicating that with high silica-low solid waters the cost is not great, and where zeolite softening equipment is already installed then a low investment is involved. The water studied contained 40 ppm SiO_2, which was lowered to an average of 5 ppm. It was found that the effluent silica was less than 1.0 ppm a major portion of each run.

Demineralization, both with and without the silica removal unit, continues to find broader application. Major disadvantage continues to be high cost of operation and as a result must be confined to essentially closed-type systems or where high purity is required. The greatest advancements have been made in regard to the efficiency of silica removal, which has been a critical consideration for use of the process in conditioning feedwater for high pressure steam boilers. An effluent silica ranging less than 0.05 ppm is generally available and essentially obsoletes the use of evaporators, both technically and economically.

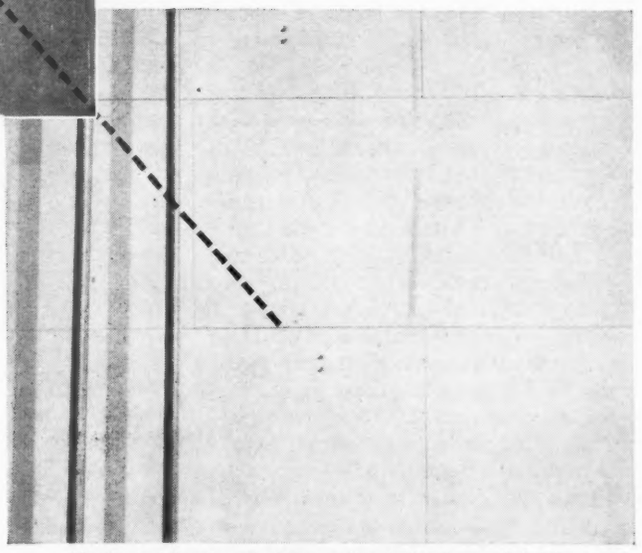
Internal Methods

Internal conditioning methods must of necessity be tailored to each specific application. These considerations include types of equipment, temperature (range and gradients), velocity, pressure, system metals, and other factors as well as the general character of the make-up water. A thorough program considers all factors of both external and internal conditioning in regard to all design and operating variables for each will bear a relationship to the others. Specific consideration must, therefore, be individual, and it is not the purpose of this discussion to consider such individual cases but to present general techniques. Proper supervision for specific application should be entrusted to those specialists





No matter how you look at it...



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in the field who possess broad knowledge based on proved technical merit.

In all water-using systems, the trend is definitely toward maximum conservation of water in use. This is mandatory in the water-short areas, but the trend is prevalent in all areas. The design of tight steam systems has been practiced for years primarily due to savings in fuel and water conditioning, but this has not always been the case with cooling tower waters. Refineries, in particular, are still being designed without proper collection and return of all cooling water streams, particularly numerous small streams such as those serving pump glands and bearings. Some designs force a heavy blowdown rate from the cooling tower system for use as catalyst wash and other general wash purposes. These losses often hold the available concentration ratio of the cooling water as low as two or less over the make-up water in use, where otherwise that water might safely be concentrated to a range of eight to fifteen times. It is true that beyond a concentration ratio of about four there is no great percentage saving in volume of make-up required. In water-short areas, that small percentage of water saved beyond a concentration ratio of four may, however, prevent a forced shutdown.

A factor of elevated concentration that is often overlooked is the savings that can be realized in cost of water conditioning chemicals at ranges beyond a concentration ratio of four. These savings can be tremendous in addition to allowing the use of more efficient inhibitors. With such a large percentage of the investment in a gasoline plant, refinery, or petrochemical plant tied up in equipment having contact with circulating waters, it is conceivable that sufficient importance should be given to the engineering design and operational control of those water streams. These are process streams that are as important as, and in some cases can become more important than, the actual feed-stock and product-streams. The water streams warrant as much engineering thought and operational control as any of the process streams. Therefore, the trend toward maximum utilization and control of the water streams is wise regardless of whether the threat of water shortage is prevalent.

pH or alkalinity control of industrial circulating waters is always a major consideration, and with cooling tower waters this is usually a critical control since both precipitation control and function of corrosion inhibitors are usually involved. The control range for optimum conditions is rather confined, and fluctuations beyond the established limits are not desirable and, in most cases, cannot be tolerated. In view of the importance of this control, the development of automatic pH control systems has made considerable progress in recent years. Expense of such equipment generally limits its use to larger systems, but under no condition does it replace operator responsibility for checking the pH and alkalinity controls on a frequent routine basis. The automatic equipment is a valuable addition for control purposes as a tool in leveling out the degree of control fluctuations but should not be relied upon as a method of sole control.

Sulfuric acid continues to be the most economical internal method of adjusting pH downward. Due to its properties, it must be handled at high strength in order that mild steel and iron equipment may be employed in the construction of handling equipment for economical installation. The development of "Alloyco 20" high nickel-chromium stainless steel for construction of valving has eliminated a major problem. There continues to be no accurate proportioning pump that will stand up under the strong acid service at small percentage feed rate for prolonged life and reliability. As a result, the use of gravity feed systems is common. The use of desiccated equipment and absence of super-atmospheric pressure is recommended for maximum safety.

The use of sulfur burners or sulfur dioxide as a means of alkalinity reduction in cooling tower waters continues to find unfavorable criticism by those more experienced in the field. Water consultants generally have no competitive interest in the method used in lowering the pH value of a circulating water as long as the economics of the method are justified to the degree of corrosion protection obtained. Sulfur gases are considerably cheaper than sulfuric acid, but the startling fact remains that a majority of sulfur burners that have been installed have been subsequently removed due to inability to control corrosion in their presence. There continues to be considerable question as to the chemical combinations actually formed upon reaction of sulfur dioxide with the ions present in natural waters at the short reaction-time factor usually involved and at the gas-to-water ratios encountered. The formation of compounds capable of thermal decomposition at heat-transfer surfaces for acceleration of local corrosion or destruction of protective films is possible. The prevalent attitude toward sulfur burners is based upon experience dating back to the middle 1920's but does not preclude the possibility that the method can be developed to a reliable level. The presence of sulfur burners around a plant working with inflammable products must be considered, however, with extreme caution.

pH adjustments made to a circulating industrial water are not for the specific purpose of adjusting to a control by some saturation index. The Langelier saturation index and modifications thereof have proved impractical as a control method in systems where the water is engaged in heat transfer. Such indexes simply express the chemical equilibrium found to exist in regard to calcium bicarbonate in water solution. The ratio of carbon dioxide to lime in a solution of calcium bicarbonate will not, in general, correspond to the formula $Ca(HCO_3)_2$, since in the absence of an excess of carbon dioxide the calcium bicarbonate is metastable.

The indexes are simply an expression of the quantity of excess carbon dioxide that is available. If insufficient excess is present to stabilize the calcium bicarbonate to prevent it from forming calcium carbonate, then the solution is theoretically scale forming and said to have a "positive index." If, however, there is an excess of carbon dioxide over that required to stabilize the calcium bicarbonate, then this additional excess is said to be aggressive or corrosive and the solution is said to have a "negative index." The excess carbon dioxide required to stabilize a given quantity of calcium bicarbonate is, however, not a constant but is a variable dependent upon temperature, quantity of all forms of alkalinity, and quantity of all forms of other salts in that solution. For a given solution at a given temperature, the index can be determined experimentally, and the method has been of considerable value

The Author

Joseph W. Gibson is service director and supervisor of laboratories and a member of the staff of the technical department of D. W. Haering and Company, Inc. He was graduated from Ouachita College and took postgraduate work at Northwestern University before joining the D. W. Haering organization in 1940 as a field service representative. Upon return from service after World War II, Gibson was placed on the technical staff of the general office of the Haering Company. His broad knowledge of the theory of scale and corrosion control is complemented by plant-level experience in the practical application of corrective measures.

in the control of transfer pipe line corrosion where no heat transfer is involved.

The index method is an impractical control point in regard to water serving heat transfer equipment because no constant temperature and no constant dissolved solids content is encountered in the water being recirculated. The temperature factor alone based on the temperature gradients encountered in the flow of water from the inlet of a condenser to the discharge is sufficient assurance that no constant saturation index is encountered. Alkalinity and concentration of dissolved salts constantly vary, if additional proof is needed.

The principles behind these indexes, however, may be used to explain reactions occurring in the water treatment program in use. The sequestering action of phosphates or the complexation action of organics may be used to counteract the precipitation of carbonate at hot spots and other "positive" areas while corrosion inhibitors may be relied upon for protection at colder "negative" areas. On the other hand, the pH range used may not be based on a calcium carbonate principle at all but on the solubility of calcium phosphate or some other compound. Again it may not be based on the optimum solubility range of any precipitable salt but may be based upon reactions involving the formation of protective films by inhibitors against corroding metals.

The complex design of heat exchange equipment employed in the gas and oil industries influences corrosion control factors and, at the same time, imposes a more imperative demand for improved corrosion protection to expensive equipment. A single system may involve several types of equipment embodying many variables in composition of metals, velocity flows, retention time, temperature, and temperature differentials. The presence of these variables at heat transfer surfaces considerably complicates corrosion control since major inhibitor reactions occur at the water-metal interface of corroding metals. The solution density of inhibitor required at that interface against the lattice structure of the heat-flow energized metals is of primary importance. It is essential, therefore, that the environmental factors existing in the main body of the water be brought into adjustment to produce an interface influence favorable to the formation of films providing the maximum degree of protection.

Since environmental control is an important factor, the establishment of a set of controls more readily maintained within such a range is desirable. Therefore, near neutral pH ranges are to be preferred over more acidic ranges, where possible, since the control is more readily held within steady ranges if wider fluctuations in alkalinity can produce narrower fluctuations in pH control. Corrosion control supplements are often used to increase the durability of protective films under those fluctuating margins of control.

The Glucosates,* particularly Quachrom Glucosate and modifications based on the Quachrom Glucosate molecule, have wide application where complex environmental factors are involved. The capacity of these molecules for forming highly elastic films, having broad coverage and good bonding properties to the lattice structure of metals, and possessing a high degree of effectiveness over a wide range of control conditions is responsible for their employment in refinery corrosion control for more than twenty years. Since the early 1930's, the Chrom Glucosates and Phospho Glucosates have been used in combination for complexation into organic structures of polymerized molecules of high weight to form film characteristics different from those formed when each is used singly. The wide-spread adoption, in recent years, of similar control measures is testimony to the basic soundness of pioneering work which emerged from the experimental phase nearly a quarter of a century ago.

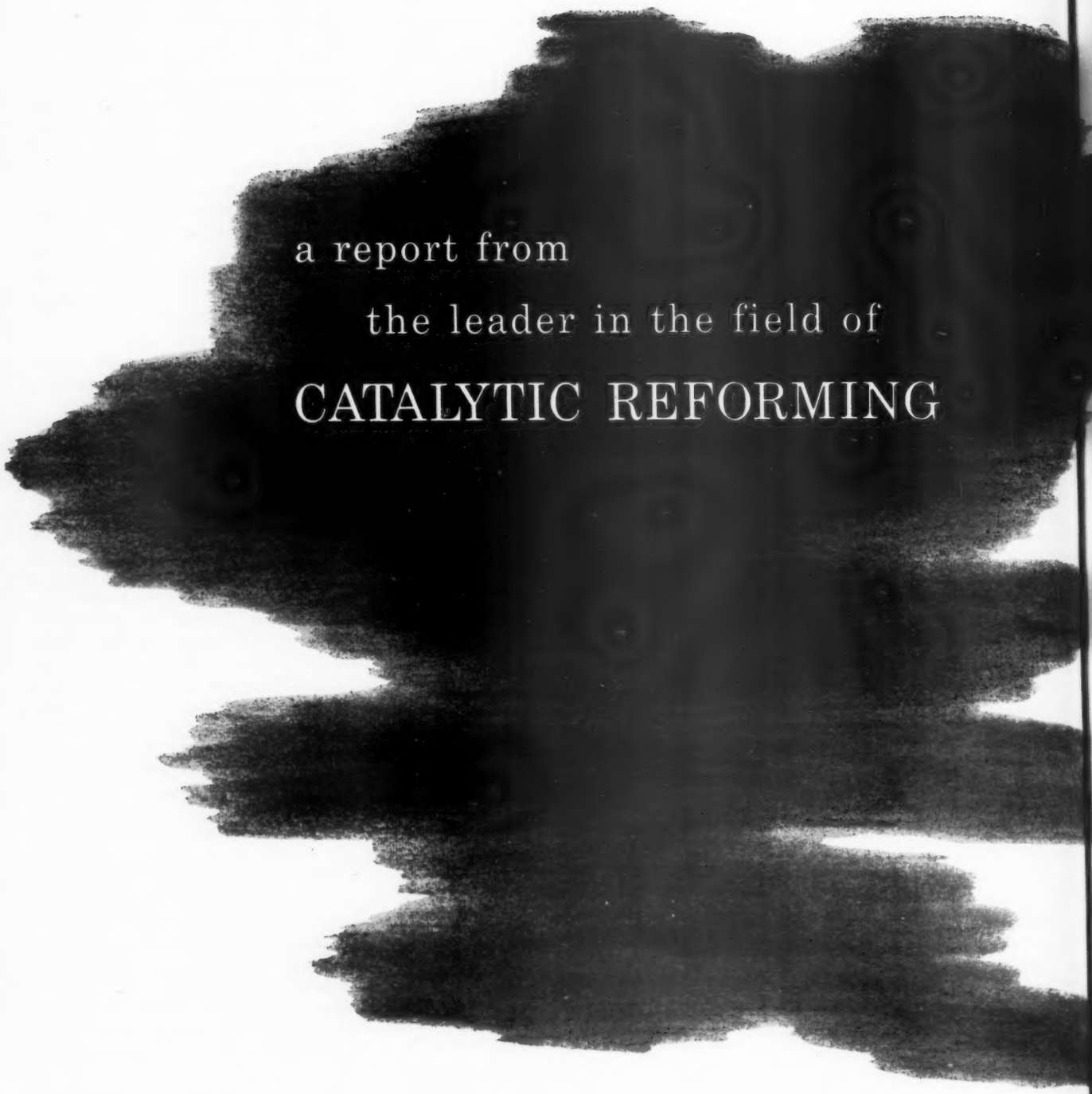
Control of microorganisms is essential for proper control of all recirculating waters. Chlorine continues to be the most effective and economical method of control. Its use is preferred on a continuous-feed basis, and the economics involved warrant continuous use. Shock treatment with chlorine and other strong oxidizing agents, is not generally advisable due to action of chlorine on wood and an ability to strip protective films, both natural and inhibitor produced, from the metals being protected. Application of shock treatment has been recommended in several cases, using a specific control for each particular system so treated. Shock treatment methods are better confined to non-oxidation type biocides such as the chlorophenates and some forms of copperated chemicals. Sodium pentachlorophenate is widely used on a shock-dosage basis although care needs to be exercised in assuring an optimum pH range and sufficient residual for an effective kill rate. Various quaternary and other amines are in use but their effectiveness on higher-order algae and protozoa found in some areas in industrial circulating systems can be questioned. Many new compounds, particularly organics, are under investigation. A fungicide based on the compound dichloro (2, 3-dichloro-1, 4-naphthoquinone) has shown preliminary promise on some forms of algae found in industrial waters as well as on some forms of fungi, bacteria, and pseudo-bacteria at low-dosage rate and over a broad pH range.

Treatment of boiler feedwater continues to stress an increased purity of feed stock and closer analytical control over the conditioning program. The trend toward higher pressures and design of boilers with smaller tubes for accelerated steaming rates at higher circulation velocities has forced a more critical control over scale and corrosion factors. The broader use of superheated steam and increased complexity of steam flow and services has brought a greater demand for increased steam purity. A greater emphasis has, therefore, resulted in broader use of external conditioning equipment.

Internal conditioning of boiler waters continues to stress the removal of dissolved oxygen and the control of scale by means of phosphates. The use of orthophosphates is essentially obsolete since major emphasis is on the use of higher phosphates, both meta and pyro phases. Removal of dissolved oxygen continues to be based primarily on the use of sulfite although the use of hydrazine has increased. The need to accelerate the speed of the reaction between sulfite and oxygen has resulted in the use of catalyzing agents in some cases. Organic sulfites, such as the Sulpho Glucosates, are efficient oxygen scavengers with a rapid reaction rate. They can be used at low dosage since the organic radical is oxidizable, and they need not be used on a strict proportionate-weight basis.

The use of organic molecules, which was the subject of scorn not many years ago, is now finding widespread application, even at elevated boiler pressures. Organic phosphates, such as Pyro Glucosate and other Phospho Glucosates, are simple and efficient chemicals for combining the desirable properties of organic agents with higher phosphates. Silica control is often a limiting factor since it will volatilize and enter into gaseous solution with super-heated steam to be subsequently deposited at points in the steam flow. At pressures generally below 800 psi, the major concern, however, is in deposition of silica as boiler scale since its solubility is inversely proportional to temperature. Maintenance of low silica concentration is not necessarily the only method of silica control since the use of Beta and Pyro Glucosates to carry a dissolved silica content of 200 ppm at 650 psi pressure and greater than 500 ppm at 185 psi pressure without forming scale is a matter of unpublished record in the files of the author's company.

*Registered U. S. Patent Office.


a report from
the leader in the field of
CATALYTIC REFORMING

MUCH HAS TRANSPIRED since Universal Oil Products Company announced in March, 1949, the availability of Platforming—the catalytic reforming process which pioneered the use of a platinum catalyst and which established catalytic reforming as one of the basic refining processes. Just seven months after this announcement, the first commercial unit was placed on stream. Since that time the process has received an unsurpassed acceptance throughout the world's petroleum refining industry.

The unprecendented recognition given to this catalytic reforming process is indicative of how well it has fulfilled the industry's need for an economical and efficient method to up-grade low-quality napthas. Platforming's adaptability is brought out in the sizes of the units which have been installed. With capacities ranging from 500 to 29,000 barrels, the UOP Platforming process has proved to be an answer to refiners' octane problems, no matter what the scope of their operations might be.

Recognizing that the ever-increasing demands for higher octanes would place additional burdens on the petroleum refining industry, Universal continued its studies in catalytic reforming. The results of this work were announced last March, with the introduction of Rexforming.

This newest catalytic reforming process will permit refiners to produce fuels of any useful octane rating, without limitations due to feed stocks. Laboratory and pilot plant tests have shown Rexforming to be capable of producing gasolines in excess of 100 clear octane.

Commercial acceptance of Rexforming has been immediate. Units are now being engineered and construction on these installations is scheduled to begin shortly.

The future for catalytic reforming is certainly one of continued growth and progress. It is a future in which Universal Oil Products Company will play a leading role.

UNIVERSAL OIL PRODUCTS COMPANY

UOP

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Universal Service
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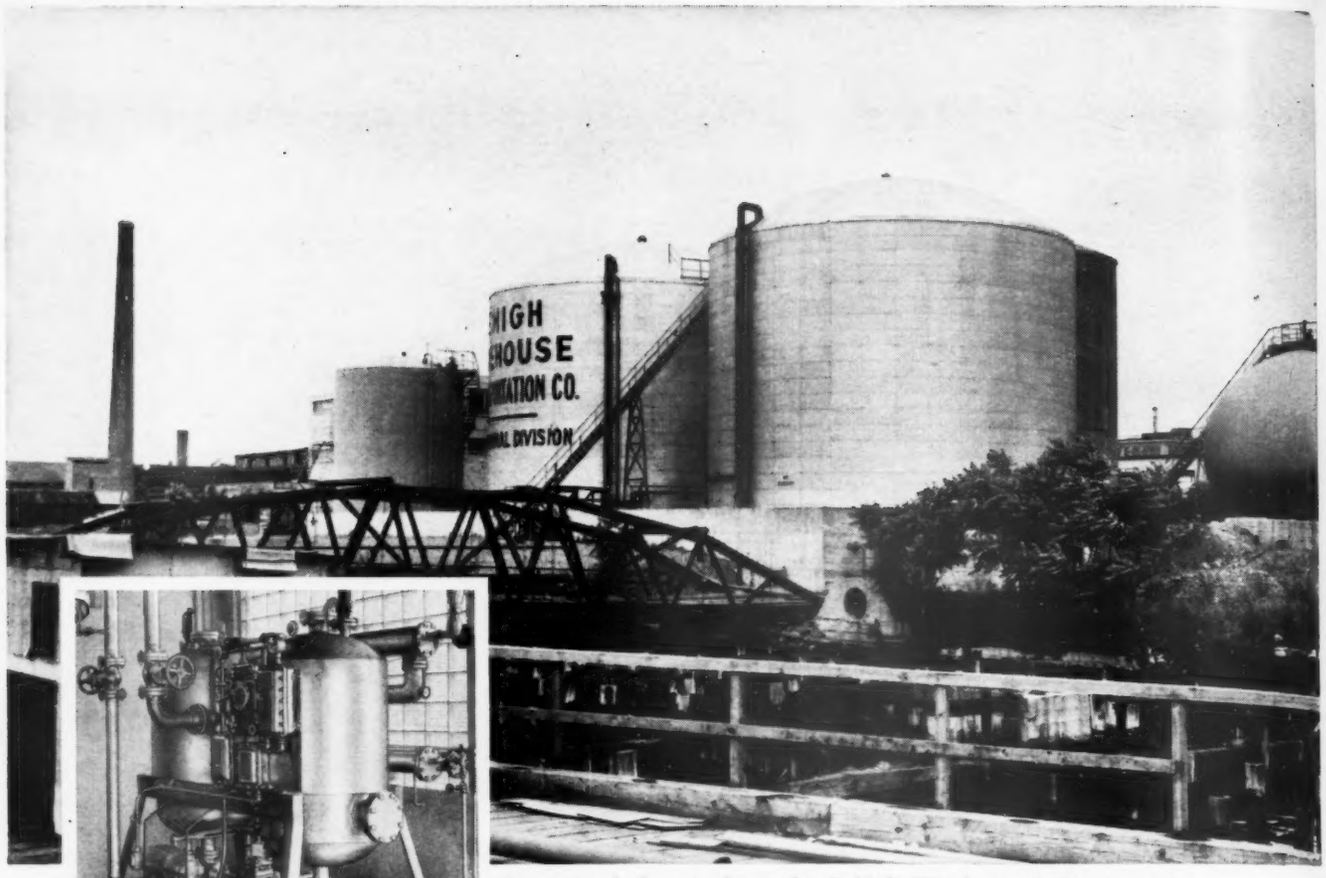

In seven of these tanks at this Lehigh Warehouse & Transportation Company terminal at Bayonne, New Jersey, a blanket of DRY *air can be maintained to prevent contamination of their contents by moisture.*

◀ Type BY Lectrodryer for DRYING compressed air.

DRY air blankets products stored at this terminal awaiting trans-shipment

Tank cars arriving at this terminal are washed out with steam and then flushed with compressed air until they're dry. Thus they make certain there'll be no contamination of materials being loaded into these cars.

To safeguard any products stored here which would pick up moisture from the air above them, the tanks are kept flooded with DRY air at 30-pounds pressure. This positive pressure inside the tanks prevents infiltration of moist air from the outside. Product quality is preserved.

A Lectrodryer dries air as it comes from the compressors at 100-pounds pressure and feeds it to the storage tanks. Completely automatic, its DRYing-regeneration cycle is reversed every three hours to keep it working at top efficiency.

Whatever your DRYing problem—air, gases or organic liquids—there's a Lectrodryer capable of handling it. The book, *Because Moisture Isn't Pink,* describes installations in dozens of industries. For a free copy, write Pittsburgh Lectrodryer Corporation, 334 32nd Street, Pittsburgh 30, Pa.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
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LECTRODRYERS DRY
WITH ACTIVATED ALUMINAS

LECTRODRYER

* REGISTERED TRADEMARK U. S. PAT. OFF.

Steam and return-line corrosion continues as a major problem. Treatment of steam and return condensate has been practiced since the early 1930's, but there continues to be no satisfactory method of control unless the boiler feedwater conditions are first corrected to provide a good quality of steam. Major difficulty can be traced to oxygen and carbon dioxide in the generated steam, and these are factors that should more properly and more efficiently be corrected at the boiler through proper treatment of the boiler feedwater. Carbon dioxide is the greatest offender. Where this source of contamination does not originate from the boiler but rather from some source in process, then that stream can be neutralized separately.

Closed recirculating systems, such as for engine jackets and lube oil cooling, should employ high-quality water from good steam condensate or demineralized source. Conventional engine-cooling design is for operation at 170 to 180 F. At such temperature, any calcium and magnesium cations are subject to precipitation as either scale or sludge. Since the systems have essentially no water loss, then the expense of high-quality water is warranted. This precipitation factor has become more critical with the advent of engines operating on vapor-phase or ebullient cooling. Where the make-up quality eliminates the presence of precipitable ions, then subsequent treatment with a corrosion inhibitor is sufficient.

Vapor-phase or ebullient cooling of engine jackets is relatively new and warrants some comment. This type system circulates water maintained at its boiling point, and as a result, there is no temperature differential of the water passing across the heat exchange surfaces. Instead, cooling is accomplished by the water-absorbing heat as latent heat so that the water, instead of increasing in temperature, converts from the liquid to the gas (steam) phase by the addition of that latent heat of evaporation. Therefore, in Btu content, a given volume of water can absorb many times more heat than when operating upon the absorption of sensible heat. As liquid water, at boiling point, enters the jacket chamber, the absorption of heat to form steam results in a water-gas mixture of lower specific gravity than the influent water and, therefore, results in natural thermal circulation of the water. Circulating pumps can normally be eliminated from the circuit. The water-steam mixture from the jackets passes to a flash tank, where the steam is flashed out to an air-cooled condenser. Condensate from this condenser, being below boiling temperature, is injected into the water-steam mixture returning from the jackets, and this blending serves to condense some steam in the mixture and elevate the condensate to boiling point, thereby maintaining constant boiling temperature on the circulating water. Such an installation is analogous to a steam boiler where the engine jackets are analogous to boiler tubes, flash tank analogous to steam drum, etc.

The resultant very low velocity of water through the jackets and the hotter temperatures involved make it imperative that maximum purity water be used. It is impossible to prevent the precipitation of calcium and magnesium, and if encountered, these can at best only be converted to a sludge, which is still undesirable. Also, residual alkalinity is rapidly converted to carbonate and hydroxide for a considerable elevation of pH. Elevated pH is undesirable since the engines at present cooled by this method are those of conventional design for operation at higher velocities and lower temperatures. A low total solids content is desirable. The system water should be treated with a corrosion inhibitor, and care should be exercised to maintain a sodium content at low level. The use of Acid Chrom Glucosate for corrosion inhibition in these syetems is commonly practiced since pH values should not be raised.

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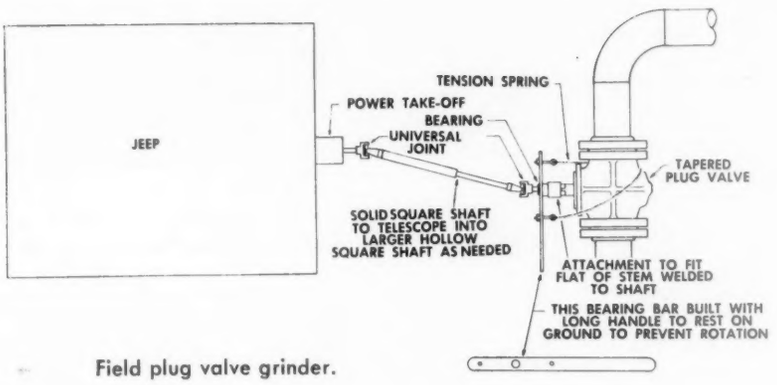
* * *

Analytical Method

Field Plug Valve Grinder†


JEEP
TENSION SPRING
POWER TAKE-OFF
BEARING
UNIVERSAL JOINT
TAPERED PLUG VALVE
SOLID SQUARE SHAFT TO TELESCOPE INTO LARGER HOLLOW SQUARE SHAFT AS NEEDED
ATTACHMENT TO FIT FLAT OF STEM WELDED TO SHAFT
THIS BEARING BAR BUILT WITH LONG HANDLE TO REST ON GROUND TO PREVENT ROTATION

Field plug valve grinder.

W. B. BOWEN§§

A jeep, tractor or other vehicle with power take-off is required. Come off the power take off shaft with a universal joint, to this attach a telescoping shaft, or flexible shaft, (shaft can be made of two pieces of square stock, one small enough to slide inside the other.) To this shaft attach another universal, and on its end attach a fitting that will fit the flat of the stem of the valves to be ground. Remove the core of the valve, put on compound, place in prepared slot and back vehicle up to front of valve body, place core in body and rotate in reverse and low gears at about one minute intervals.

To maintain proper tension take a steel bar 2 in. by ¼-in. by 36 in. At one end cut a small hole, about 6 in. from this hole drill or cut a hole large enough to fit the shaft just back of the slotted fitting on the valve core stem, then 6 in. from this hole cut another small hole, get a piece of inner tube rubber 3 in. wide or spring of proper length, attach a wire hook on each end of this spring or band, hook these hooks in the steel bar after it is placed on the shaft, passing it around the valve body. The long end of the steel bar may rest on the ground or held to prevent its rotating. A flexible shaft will be required to grind valves in boxes or deep under ground, the above is especially adapted to meter run valves.

§§Panoma Corporation.

†Class D, first prize and grand prize, NGAA—Panhandle-Plains Regional Meeting, Amarillo, Tuesday, November 20, 1951.

Skelly Replaces Magnetos

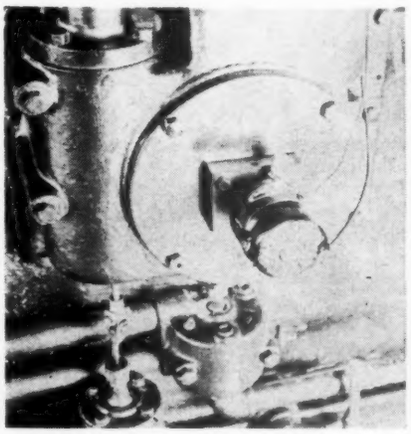
With Battery Ignition

J. C. Albright

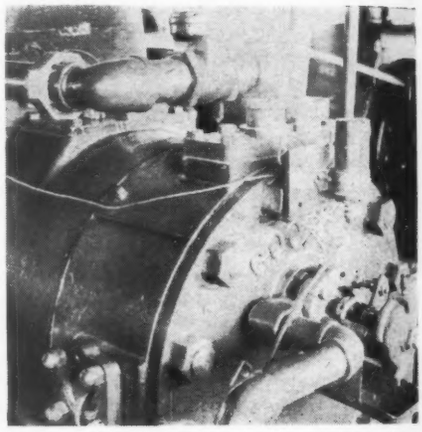
BATTERY ignition, to replace worn magnetos, has been applied by Skelly Oil Company to various types and manufacture of two cycle, horizontal gas engines in some of its natural gasoline plants. In the plant at Cunningham, Kansas, there are seven Type 10 Cooper-Bessemer gas engines directly connected to compressor cylinders. To produce the necessary electrical current for various requirements, there are five Western gas engines directly connected to a-c generators. These engines were originally equipped with high tension magnetos that functioned excellently while they were in good condition. Constant use over a period of years, brought about misalignment of many rotating parts, interfering with the production of a hot, fat spark for the power cylinders. The expense in time, labor and replacement parts, such as breaker sets, magnets, field coils, and armatures and impulse units on the magnetos became increasingly greater, and then came the time for a decision to be made.

Since the time that battery ignition had been applied to automobile engines, the service this type of ignition has given has been so uniformly satisfactory that an average car will run for months without overhauling the ignition system. Therefore, it was decided that if a satisfactory application of automotive type battery ignition unit could be attached to these relatively slow rpm stationary engines, running at an average between 180 to 200 revolutions per minute, much of the ignition difficulties might be eliminated. The majority of automotive vehicles, particularly passenger cars, are six cylinder units supplied by the company, and it was only natural that one of the spare distributors applicable to this type of vehicle was selected for the timing device for battery ignition on the heavy gas engines.

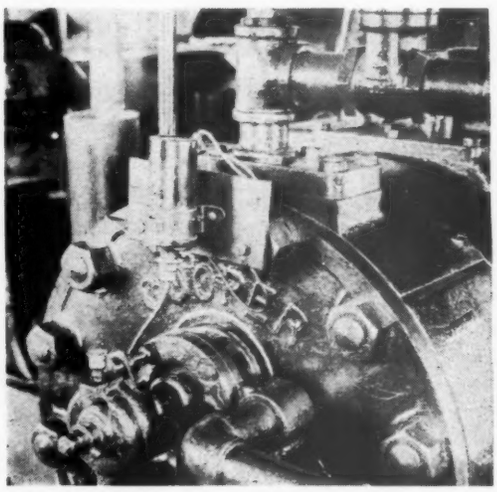
Obviously, since the power units in the engine room were two cylinder, two cycle, the cam in the original distributor would not be satisfactory. A conversion of this part was made by removing the standard six lobe cam and replacing it with a cam having only one lobe. The breaker plate was removed also, and a plate carrying two sets of points directly opposite each other was placed in the distributor housing. The single lobe cam rotating at crankshaft speed strikes the rub block on the movable point to break the circuit at intervals of exactly 180 deg apart. The type distributor unit employed on the Cooper-Bessemer is a Delco-Remy No. 7021, obtained complete with body, cam, rotor and distributor cap. The rotor is not installed since the secondary current is not returned to the distributor, and the sockets of the cap were sawed flush with surface and plugged with battery asphalt cell sealing plastic. The caps in their present job are that of only covers to keep the breaker points free of dust and moisture. As there is no necessity for a vacuum advance on any two cycle engine, this unit was obtained with the distributor. But the mechanical fly-ball

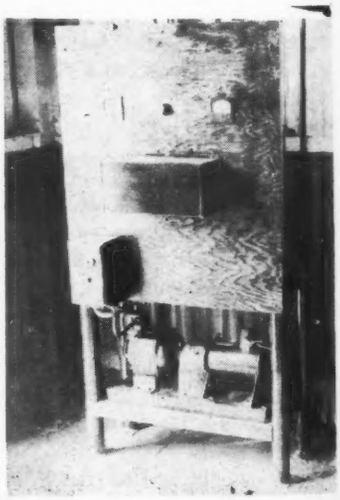


Delco-Remy No. 7021 6 cylinder auto distributor set into crankshaft. Two primary wires lead to two cylinders.



Shows length of secondary cable from ignition coil to sparkplug; no longer than average automobile sparkplug wire.





Bracket supporting coil, condenser is attached to cylinder head bolts with capscrews. Right, equipment in Skelly Oil battery ignition applied to Western & Cooper-Bessemer horizontal 2 cycle engines. Below panel is ½ hp 220 volt, 1725 3 phase motor driving 35 amp Autolite external control 6 volt automotive generator. Behind panel is 3 Exide 280 amp hr "Tytex" glass cell batteries.

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type advance mechanism within the body of the distributor was not removed as it is built into the unit and no reason was seen for stripping it from the battery ignition apparatus.

Attaching the distributors to the horizontal engines was not found difficult as the end of the crankshaft extends beyond the outside main bearing in the engine bedplate. A supporting bracket was shaped to fit to the plate enclosing the main journal as a mounting for the distributor in a horizontal position. The distributor was set into this bracket exactly in the same manner as it would have been had it been replaced on a six cylinder automobile. The drive slot attached to the exact center of the crankshaft permits connecting the distributor shaft so it will rotate at the same speed as that of the crankshaft. Timing for the "rough" setting was done by installing the distributor shaft drive slot so that one set of breaker points just begin to open at top dead center of one piston, so that the other piston will automatically reach dead center as the opposite set of breaker points begin to separate. The final setting of the spark timing can be done exactly as when making a final adjustment on an automobile distributor. By moving the distributor body either against rotation or by following it, the spark timing can be advanced or retarded as engine operation dictates.

The ignition coil was mounted directly above the fuel injection valve in the cylinder head. A bracket was designed that could be installed upon and supported by the two top cylinder head bolts which were drilled and tapped for cap screws. The more or less universal coil bracket, clamped to the body of the coil, was attached to the face of this bracket with two capscrews exactly as it might have been attached to the cylinder head of the 6 cylinder automobile. Each of the pair of horizontal cylinders was treated in the same manner, so that two coils are employed, one for each spark. Individual primary wires run from the connection outside the distributor body which supports and makes contact with the breaker points to the individual spark coils through a toggle switch to make or break the ignition circuit when starting or shutting down the engines.

Supplying battery current for the ignition system on the 12 separate engines was accomplished by installing a Leland ½ horsepower, 220 v a-c 1725 rpm 3 phase motor, connected in line with an Autolite 35 amp external current-voltage controlled generator. Storage of this current is accomplished with a three-cell Exide 280 amp-hour "Tytex" battery. The current generating set and batteries are contained in a small, compact unit located inside the main electric generating room where it can easily be serviced. The motor-generator combination is installed near the engine room floor on a support built within the frame, while the batteries are installed on a shelf behind the instrument panel. Controls for starting and shutting down the generator are attached to the front of the panel while two simple ammeters are set flush with the face of the board. Current from the batteries is carried to the various engines with adequate sized primary wire enclosed in standard electrical conduit.

The practicability of the application of any new and different equipment to machinery in a gasoline plant is evaluated largely by the reaction of the men who operate the plants. At Cunningham, the engineers declare that the engines start more easily and will run longer under a heavy load than formerly. Nor do they encounter any difficulty when starting an engine or adjusting the timing of the spark to the plugs. Any "new invention" must be good when it brings praise from a group of "Old Hands" who have been long accustomed to a different type of operation.

* * *

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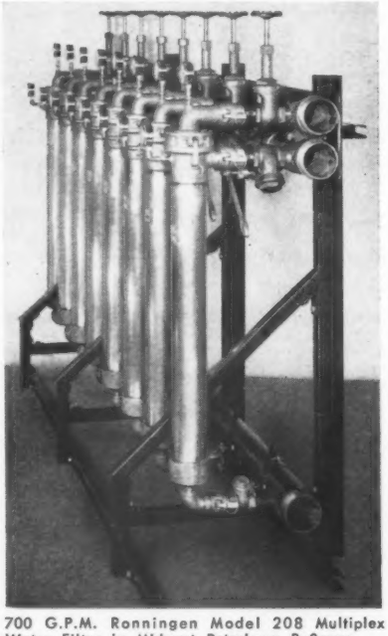

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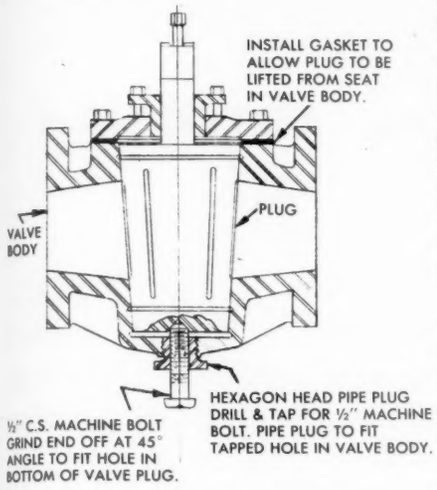
In most states, the regulatory bodies governing the handling, storage and use of liquefied petroleum gases require that the discharge piping or vent from safety relief valves on containers of more than 125 gal shall discharge verically upward and shall be equipped with fitted rain caps.


INSTALL GASKET TO ALLOW PLUG TO BE LIFTED FROM SEAT IN VALVE BODY.
PLUG
VALVE BODY
HEXAGON HEAD PIPE PLUG DRILL & TAP FOR ½" MACHINE BOLT. PIPE PLUG TO FIT TAPPED HOLE IN VALVE BODY.
½" C.S. MACHINE BOLT GRIND END OFF AT 45° ANGLE TO FIT HOLE IN BOTTOM OF VALVE PLUG.

In the past, our storage tank vents were fitted with rain caps that slipped in the open end of the discharge pipe which extended some ten feet into the air. Each time the tank popped, the rain cap was blown some distance away, was hard to find and difficult to replace unless the vent pipe was taken down.

As a plain aid, a loose fitted rain cap of the hinged type was designed that will blow back while the tank is venting, but will fall back automatically into place when the relief valve seats.

Portable Vacuum Machine[5]

SAM SUMMERS[6]

By taking a Cenco Hyvac vacuum pump and a ¼-hp 6-v dc motor and the use of a belt for driving the vacuum pump, samples of gas can be taken from vacuum lines to determine the air content with a Hays Analyzer. The vacuum pump and motor were built portable. The motor is driven by an ordinary automobile battery. The unit can be placed in a pickup and transported to any part of the field system for checking gas in main lines and lateral lines, thus saving the necessity of walking all lines checking for leaks. As a number of the new plants built today have only one incoming main line, this pump can be used for checking all laterals.

The vacuum pump is equipped with a relief valve set at approximately 1 lb pressure to protect the vacuum pump. This small unit weighs approximately 35 lb. It can be handled easily by one man; thus saving the expense of operating a test car unit for this purpose. Rubber tubing is used for connection to the vacuum lines and to the Hays Analyzer.

[5]Class B, third prize, NGAA Kinks Contest.
[6]Warren Petroleum Company, Gladewater, Texas.

Portable vacuum machine.

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Processing Plants Controlling Corrosion

Battle against damaging causative agents studied in four installations. Each is a separate problem; procedures determined by individual inspection

BRYANT W. BRADLEY

SINCE Bacon and Brown[1] first described corrosion in gas condensate wells in 1943, a tremendous amount of individual work and corporate funds have been devoted to the problem. In addition, a study of the problem was aided a great deal through the co-operative efforts of study committees in the National Association of Corrosion Engineers (NACE), The National Gasoline Association of America (NGAA), and the American Petroleum Institute (API). As a result, all phases of this type of failure have been studied thoroughly, and today it is possible to control corrosion in wells of this type at nominal costs.

This individual and co-operative study of the problem, which was started over 10 years ago, resulted in a satisfactory explanation of the corrosion mechanism, the determination of the corroding agents and how to analyze from them, how to measure or evaluate the corrosiveness of a given well, and the development of several effective and economical control measures. During the course of this work, many papers and reports have been presented and published about individual problems in certain fields. In addition, economic studies of gas condensate well corrosion have shown that very significant savings have been made by those affected by the once-serious gas production problem.[2]

A review of the published papers and reports on this subject reveals that the causative agents have been shown to be primarily carbon dioxide and organic acids. Other characteristics, such as production rate, temperature, tubing size, amount of water production, and well pressure also appear to play a contributing role in the corrosion process. These reports minutely describe and picture the damage that has been found in tubing, Christmas trees, and in some cases the immediate well head fittings and adjacent meter runs. In a few cases brief mention has been given to corrosion in gas gathering lines and plants processing the gas for cycling, resale, or removal of heavier hydrocarbons and water vapor.[3,4,5,6,7]

None of these reports, however, have given a detailed description of the corrosion problem in gas gathering lines or processing plants as was the case in the well corrosion problem. This apparent lack of attention is, of course, understandable as the cost to repair or replace well tubing and Christmas trees is generally much greater, because of rig time, than the cost to repair flow lines or plant processing equipment. In addition, there is considerable evidence to indicate that corrosion rates, and therefore costs, are lower in gathering lines and plants than in well tubing. Therefore, the purpose of this report is to briefly describe the fluid characteristics and internal corrosion damage observed in the flow lines and processing plants located in several different fields. One field is known to be a corrosive gas condensate field; another is currently classified as a non-corrosive high pressure oil field; while the others are high pressure sour oil fields. Other problems such as soil corrosion of gathering lines, atmospheric corrosion of cooling tower headers, corrosion in gas sweetening plants, and steam condensate corrosion, of course, are problems associated with gas processing facilities, but are not within the scope of this report.

The general characteristics of the plants and fluids handled in the 2 sweet gas fields are shown in Table 1. The plant in the corrosive gas condensate field is hereafter referred to as plant "A"; the other plant "B." Plant "A" had been in operation about 5 years at the time the reported data was gathered. The information about plant "B" was gathered immediately after plant start-up about 3 years ago. Plants "C" and "D," both handling sour gas from high pressure oil fields, have operated about 14 years.

Gathering System

If corrosion has been observed in the upper portions of the tubing and Christmas tree of a given gas condensate well, it is logical that similar damage might occur in the gathering lateral serving that well. In field "A" it was possible to visually inspect the internal condition of very joint in a 6000-ft gathering line serving the most corrosive well in the field after 5 years operation. This line was being taken up in the process of changing the gas injection pattern. The well had been completed with a packed-off annulus due to a casing splice, and thus had never received inhibition as other wells in the field. The upper 1000 ft of tubing had been severely corroded according to caliper surveys, and had been replaced with 5 per cent nickel tubing in an attempt to control corrosion. Severe damage to the Christmas tree and well head piping had been observed during previous inspections.

TABLE 1. Summary of plant characteristics and fluids processed.

	Corrosive condensate field Plate A	Non-corrosive high-pressure oil field Plate B
Plant capacity MMCF per day	100	125
Inlet Gas pressure in psi	2000	900
Acid gas content		
Carbon dioxide	3.0–3.8%	0.10–0.20%
Hydrogen sulfied	None to traces	None to traces
Organic acid content of produced water in PPM.	150–380	500–2000
Iron content of water at plant inlet separator in PPM	35–85	75–100
Water production to plant in bbl per MMCF	1.6–3.5	0.5–1.2
Liquid hydrocarbon production at plant in bbl per MMCF	20–50	130

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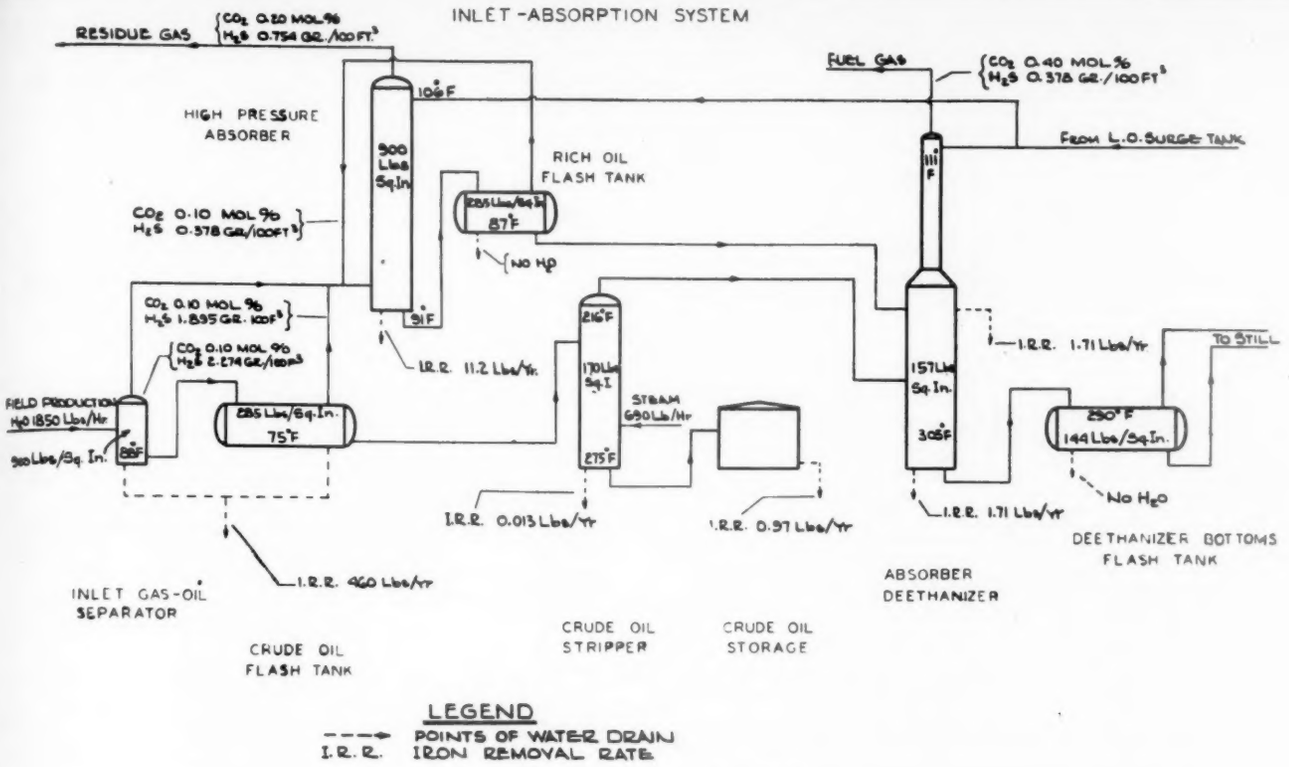


FIG. 1. Inlet-Absorption System.

The flow line inspection revealed pits 0.150-in. deep in the over-head expansion loop at the well head. Similar pits were noted in pipe immediately downstream. Many of the pits were located just downstream from welds where icicles or misalignment could have created a turbulent zone. About 3 out of every 10 joints of flow line from the well head to the first expansion loop, 2500 ft downstream, were observed to be at least partially pitted.

The expansion loop itself was pitted to a depth of 0.150-in. (34 per cent of the wall thickness) along most of its length. From the expansion loop to a point 4200 ft from the well head, the pit depth and frequency decreased. From that point to the end of the lateral (27 additional joints) no corrosion damage was present. In addition, no corrosion damage was noted in the main gathering line at the point where it was cut for alterations. Furthermore, no damage was noted in the gathering system at the plant-inlet separator and meter run. In all cases, except at expansion loops, the damage occurred along the bottom of the pipe where free water could collect or flow.

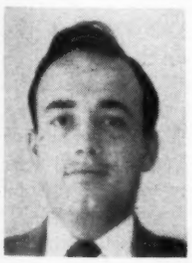
At expansion loops and bends corrosion damage occurred on the outside periphery of the bends and gave the appearance of a corroded-eroded surface. From these observations it appears that corrosiveness of the condensed water decreases as it flows from the well; a characteristic of other pipe line corrosion. Although sufficient carbon dioxide is still present to replace that consumed in the corrosion process, it is possible that corrosion products thus formed act as a buffer and reduce the corrosiveness of the water as it flows down the line.

Higher percentages or partial pressures of carbon dioxide in this particular gas could possibly make the water corrosive in the complete gathering system as reported by Frye and Clement.[6] To evaluate flow-line corrosion in field "A," corrosion coupons have been exposed throughout the system. Where residual inhibitor from the wells was not found sufficient to protect the line, or where corrosion-resistant tubing made inhibition of the wells unnecessary, lubricators were set immediately downstream from the well-heads to inject chemical inhibitors into the gathering system. Corrosion coupons, which have been used to regulate inhibitor treatment rate, indicate that one-half quart of inhibitor per 1,000,000 cu ft will control corrosion within 1-2 MPY.

In field "B" numerous well-head coupon exposures have failed to indicate any corrosion damage. The weight loss on many coupons was nil. This might be attributed to the combination of low carbon dioxide percentage in the gas, and the protective paraffin coating deposited during the exposure period. Numerous Christmas tree inspections and several tubing caliper surveys failed to reveal corrosion damage of any significance. The caliper surveys did indicate a small amount of corrosion near the bottom of the well, however. Water analyses have shown iron content of 75-150 ppm; however in view of the foregoing it was necessary to conclude at that time that the iron was either in the formation water or picked up by more-or-less uniform corrosion in the tubing and gathering

The Author

B. W. Bradley is a mechanical engineer on the corrosion-water treating staff of Shell Oil Company in New York City. Graduating from Rice Institute, Houston, Texas with a BS in chemical engineering in 1944, he spent 2½ years in the Navy. After discharge he went back to school and received a master's degree in business administration from University of Texas in 1949. Before final receipt of this degree he joined Shell (October, 1948) as a mechanical engineering trainee. Since completing that special training he has busied himself with studies in the corrosion field, some of the results of which are presented for the first time, in print, in the accompanying article, replete with practical, first-hand information of primary interest to every refiner in the industry.



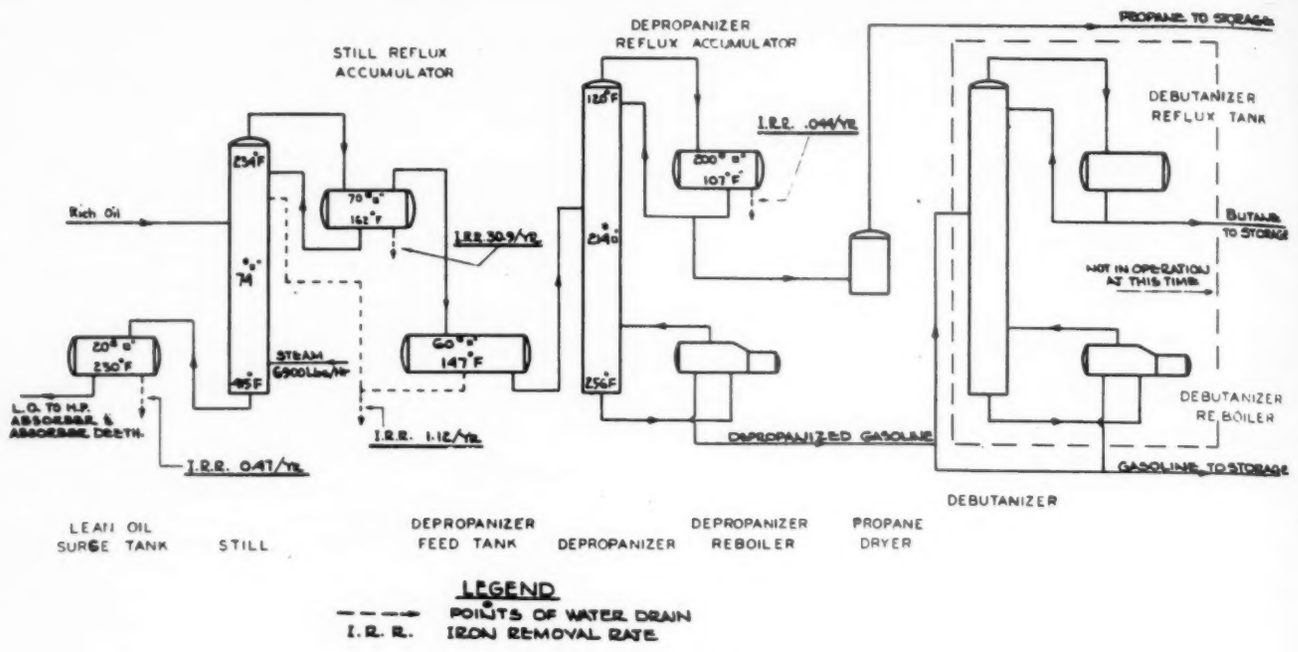


FIG. 2. Distillation-Fractionation System.

system. Short pieces cut out of several flow lines failed to reveal any internal attack, although a localized soil corrosion problem was observed in this manner.

Process Vessels

In order to obtain a preliminary evaluation as to the location and extent of corrosion occurring in plant process vessels, a technique used in refinery operations for this purpose was employed. It consisted of determining the iron content of the water drained from vessels at various points in the system. After measuring the rate of water removal at these points, it was possible to calculate an iron removal rate for each portion of the plant. Analysis of the water for pH value and carbon dioxide content also provided additional data which aided in understanding where corrosion might be occurring.

Figs. 1 and 2 are simplified flow sheets of plant "B" that show the major process vessels and points of water drain. Although not shown it is of interest to note that organic acids are apparently carried by the hydrocarbon phase through the plant where they are partially given up to the various water streams. Table 2 summarizes the findings at the two plants. Although the calculated iron removal rates at the inlet scrubber of both plants indicate corrosion might be occurring, it is very difficult to determine the exact location of corrosion by this method due to the large amount of tubing, pipe, and vessels in contact with water upstream of the sampling point.

TABLE 2. Summary of pH values, iron, carbon dioxide in water, and iron removal rates from process vessels at plants A and B.

	Plant A				Plant B			
Vessel	pH	CO_2 in ppm	Fe in ppm	Iron removal in lb per year	pH	CO_2 in ppm	Fe in ppm	Iron removal in lb per year
Inlet scrubber-flash tanks	5.1–6.1	<250	35–85	35	7.0	180	75	46
Absorber	a	—	—	—	6.7	59	9	11
Crude oil stabilizer	b	—	—	—	8.4d	0	0.1	<1
Rich oil deethanizer	b	—	—	—	6.9	10	2	4
Still water drain	7.8c	5	8	13	8.7d	0	0.1	<1
Still reflux tank	6.8	40	10	512e	7	6	1	31
Gasoline make tank	6.1	120	35	197	8.7d	0	0.1	<1
Deethanizer reflux tank	6.0	<250	175	117	f	—	—	—
Depropanizer reflux tank	6.3	12	12	1.4	7.2	10	0.2	<1

a. No water accumulates in this vessel.
b. Vessel does not appear in this plant.
c. This pH value believed due to soda ash feed to still reflux system which could find its way to still in reflux system.
d. These pH values are unaccounted for.
e. Iron removal rate before addition of soda ash in condenser was approximately 1800 lb per year.
f. Equipment not in use at time of the survey.

In view of the previously mentioned flow line inspection, it would be logical to assume that the corrosive tendency of the water has probably been reduced to an insignificant level at some point in the gathering system after leaving the well and before reaching the plant. Therefore, very little corrosion, if any, is expected in or near the plant inlet in these two cases as long as the produced water is present in the system.

Corrosion coupons exposed in the main gathering lines at plant "A" have substantiated this theory. Corrosion coupons have not yet been exposed in the gas inlet stream at plant "B," but in view of the observations made in the wells, flow lines, and points in the plant, it appears that corrosion will probably be a minor operating problem in the plant inlet system.

Although the iron removal calculated for the vessels shown in the plant inlet absorption area could be that carried by the water with the gas, all water drained from vessels downstream from the still is primarily condensed water, which enters the process as stripping steam in the still. Therefore, all iron removed by the water downstream from the still can be assumed to be the result of corrosion in that particular portion of the plant. Whereas the iron in the water drained from the vessels of the inlet absorption section could be from corrosion in those vessels, the gathering system, the well tubing, or even formation water. In view of the information previously mentioned about corrosion in the gathering lines, it was possible to assume in these two plants that vessel corrosion

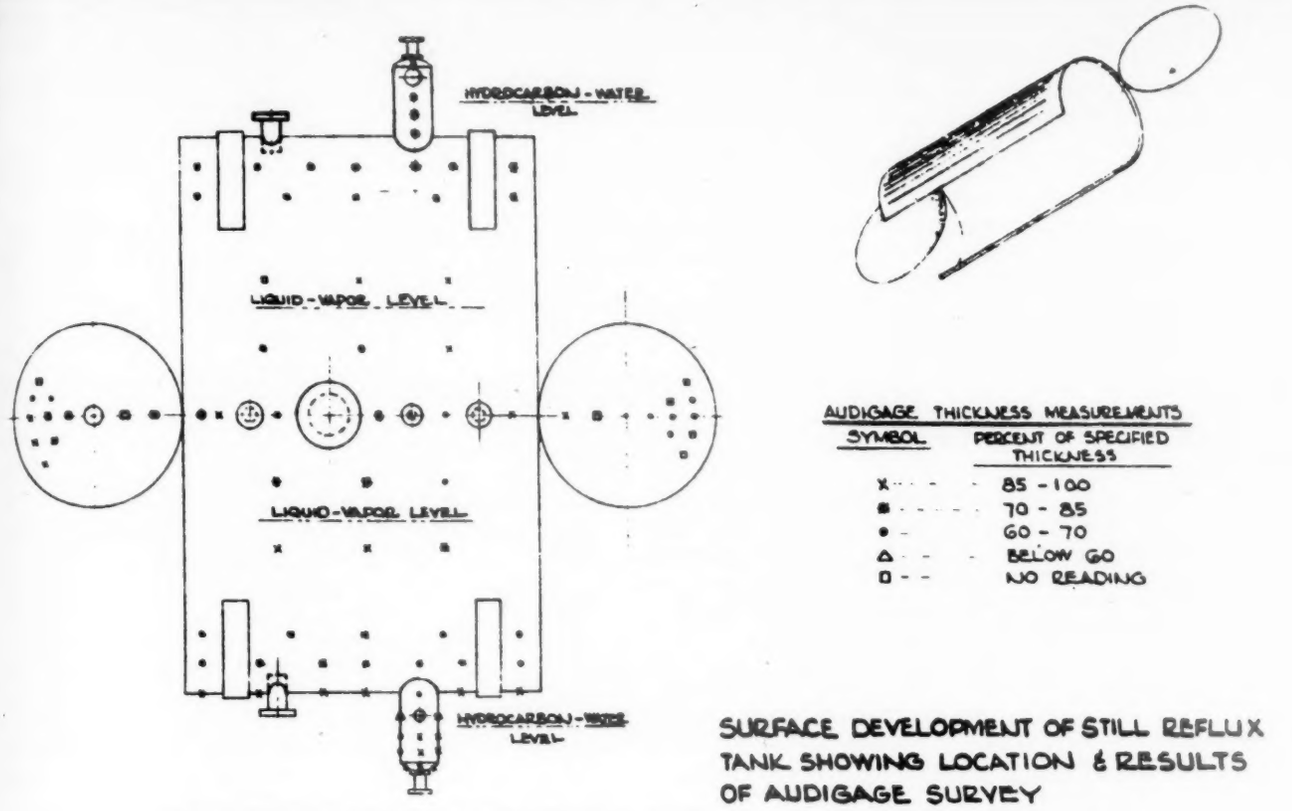


FIG. 3. Surface development of still reflux tank, showing location and results of audigage survey.

was probably not occurring in the gas inlet absorption area. Subsequent internal vessel inspection at these two plants substantiated this assumption.

As shown in Table 2 for plant "A," the highest iron removal rate was observed in the still reflux tank where the water, which contained 40 ppm carbon dioxide, was drained from the vessel at about 6000 lb per hour. The major source of this water was the stripping steam used in the still; the carbon dioxide was carried into the system principally from the absorber by the absorption oil and released during the stripping operation. Upon condensation the water in the reflux condensers redissolved the carbon dioxide causing corrosion of condenser outlet headers which required replacement about every five months during the first four years of operation. The cost of this corrosion was estimated to be about $10,000 per year. Upon addition of 15 ppm of soda ash to neutralize this water, however, the iron content dropped from 34 ppm to 10 ppm and the condenser outlet header failure frequency decreased. The cost of corrosion and inhibitor was estimated at $3200 a year at that time.

Although the iron removal rates in the gasoline make tank and deethanizer reflux tank in plant "A" were not high when compared to the still reflux tank, the soda ash inhibitor experience indicated that reduction in the iron content of the water from these vessels might be economically desirable if localized corrosion or pitting type attack were occurring in these systems. Such attack, however, was not indicated by experience as shown by subsequent investigations and discussed in the following section. It is significant to note that the carbon dioxide content of the water drained from the gasoline make tank and deethanizer reflux tank increased as the operating pressures of these vessels; and that the iron content likewise increased presumably because of the more corrosive nature of the most highly charged water.

Audigage Survey

In order to further evaluate the condition of vessels in plant "A," which was felt advisable as the plant had been operating under these conditionss for five years, an Audigage survey was conducted on the vessels where significant iron removal rates had occurred. The newness and lack of apparent corrosion indicated by the iron removal rates in plant "B" made such a survey less imperative, although Audigage data would have been valuable from an original survey metal thickness standpoint. The Audigage is a sonic instrument that measures metal thickness by determining the fundamental frequency of vibration of the test specimen. Examples of the accuracy and sensitivity of this instrument are shown in Table 3.

TABLE 3. Comparison of Audigage and micrometer measurements on steel specimens of various thickness.

Specimen No.	Thickness in inches: Micrometer	Audigage	Error	Per cent audigage error
1	0.142	0.142	0	0
2	0.250	0.253	+.003	+1.2
3	0.258	0.258	0	0
4	0.298	0.301	+.003	+1.0
5	0.330	0.329	−.001	−0.3
6	0.517	0.519	+.002	+0.4
7	0.806	0.817	+.011	+1.4
8	0.991	0.997	+.006	+0.6
9	1.086	1.105	+.019	+1.7

A survey was conducted on the still reflux tank, gasoline make tank, deethanizer reflux tank, a propane storage tank, and the still condenser outlet headers. An example of the records maintained on each vessel is shown in Fig. 3, which illustrates the reduction in metal thickness experienced by the still reflux tank in plant "A." As shown in Fig. 3 the frequency of Audigage readings was increased along the bottom of the vessel and the water accumulation leg as it was felt that the major part of any corrosion would be occuring in that area. The test results, however, indicated that corrosion occurred throughout the tank at various rates.

A comparison of the iron removal rates and Audigage thickness readings,

shown in Table 4, clearly indicates the correlation between iron removal rates and loss in thickness due to internal corrosion. For all practical purposes only the still reflux tank had suffered any reduction in thickness below the original specifications. The few readings that indicated loss of thickness in the gasoline make tank and propane storage tank showed more than 95.7 per cent and 97.6 per cent, respectively, of the original construction thickness still remaining.

The construction thickness in each case was greater than the specified thickness, which provided more than sufficient remaining thickness to comply with the API-ASME Unfired Pressure Vessel Code. As both iron removal rates and Audigage measurements indicated accelerated attack in the still reflux tank, a visual internal inspection was conducted during a plant shutdown. Observations made at that time confirmed the previous corrosion detection measures (i.e., the calculated iron removal rates and the Audigage survey), however, as the minimum thickness observed was still within API-ASME Code allowable for unfired pressure vessels operating at these conditions, the vessel was continued in operation.

TABLE 4. Comparison of the iron removal rates and Audigage metal thickness measurements after five years operation at Plant A.

Vessel	Iron removal rate in lb per year	Total number of Audigage readings on vessel	Number of readings showing: Less than 75 per cent of design thickness	75-100 per cent of design thickness	Above design thickness
Still reflux tank.....	512a	85	18	56	11
Gasoline surge tank.	197	140	0	11b	129
Deethanizer reflux tank.	117	75	0	0	75c
Propane storage tank...	—	55	0	12d	43d

a. Iron removal rate before soda ash inhibition was approximately 1800 lb per year.
b. Least thickness measured was 95.7 per cent of vessel design thickness.
c. Seven thickness measurements were the same as design thickness.
d. Least thickness measured was 97.6 per cent of specified thickness.
Fourteen measurements were the same as design thickness.

Frequent Audigage measurements have subsequently indicated no further significant reduction in metal thickness during the past 2 years of operations with soda ash inhibition. The corrosion which was indicated by the calculated iron removal rate, of 500 lb per year, apparently is occurring principally in the piping in a uniform manner upstream from the still reflux tank as no failures have occurred. In this instance it appears that neutralization of the acidic water with a soda ash solution has reduced corrosion in this tank to a low, and possibly uniform level, and improved the service life of steel piping in headers several fold.

Recently a plant test revealed that 4 ppm of water soluble organic inhibitor and 23 ppm of soda ash would reduce the iron content of 0.2 ppm. It was noted at that time that the system quickly responded to inhibitor changes as evaluated by iron content of the drain water. The estimated cost of this treatment and any remaining corrosion was $2000 per year for a total savings of about $8000 per year.

Evaluation Methods

Approximately two years after evaluating corrosion in plant "A" by the iron removal rates and the Audigage survey, the complete plant was visually inspected for internal process vessel corrosion. The inspection results substantiated the corrosion predicted and evaluated by the foregoing methods. These two corrosion evaluation methods offer several advantages over visual internal inspection. In the first place, and probably most important, the plant can be inspected and control measures evaluated without shutting down the plant. Second, the inspection techniques are both simple and relatively inexpensive to employ. Third, quite often it is desirable to evaluate plant corrosion at suspected points where no provision has been made for corrosion coupon exposures. This technique will suffice until such fittings can be provided. Current practice is to design new plants with adequate exposure points.

Although the discussion has covered only plants in high pressure operations, these corrosion evaluation techniques could be readily adaptable to plants handling casing-head and other low pressure gas, as carbon dioxide is the corrosive agent and should behave in a similar manner in other plants. Inasmuch as the foregoing data indicate that corrosion was only significant downstream from the still, where the water was unbuffered by soluble corrosion products, the same corrosive conditions found in plant "A" could easily exist in a casing head plant handling gas containing sufficient percentages of carbon dioxide since stills, deethanizers, and other process vessels operate at approximately the same conditions regardless of the plant. In addition, there is reason to believe from experience that these corrosion evaluation techniques can be used in some plants processing sour gas, although it might at first be thought that all corrosion products in a sour plant would be precipitated as iron sulfide and flow unevenly to drain thus giving erratic iron determinations.

This was not found to be the case at Plant "C" as shown in Table 5 which

TABLE 5. Summary of raw gas composition, pH values, iron content of effluent water and calculated iron removal rates in Plant C.

Raw gas composition:
Carbon dioxide... 3.3%
Hydrogen sulfide. 1.2%

Critical pressures:
Absorber.....
Still.....

Vesse	pH value of water	Fe content of water in ppm	Fe removal rate in lb per year
(1)* No. 1 absorber.....	6.7	0	0
(1) No. 2 absorber.....	6.3	2.8	<1
(2) High pressure compression scrubber.....	6.1	1.0	2
(3) High pressure still accumulator.....	5.1	2.4	8
(4) High pressure make tank..	5.7	8.8	<1
(5) Low pressure still drain...	5.1	1.0	8
(6) Low pressure still accumulator.....	5.3	1.5	7
(7) Low pressure make tank...	7.5	0.5	<1
Deethanizer reflux tank...	5.9	2.4	<1

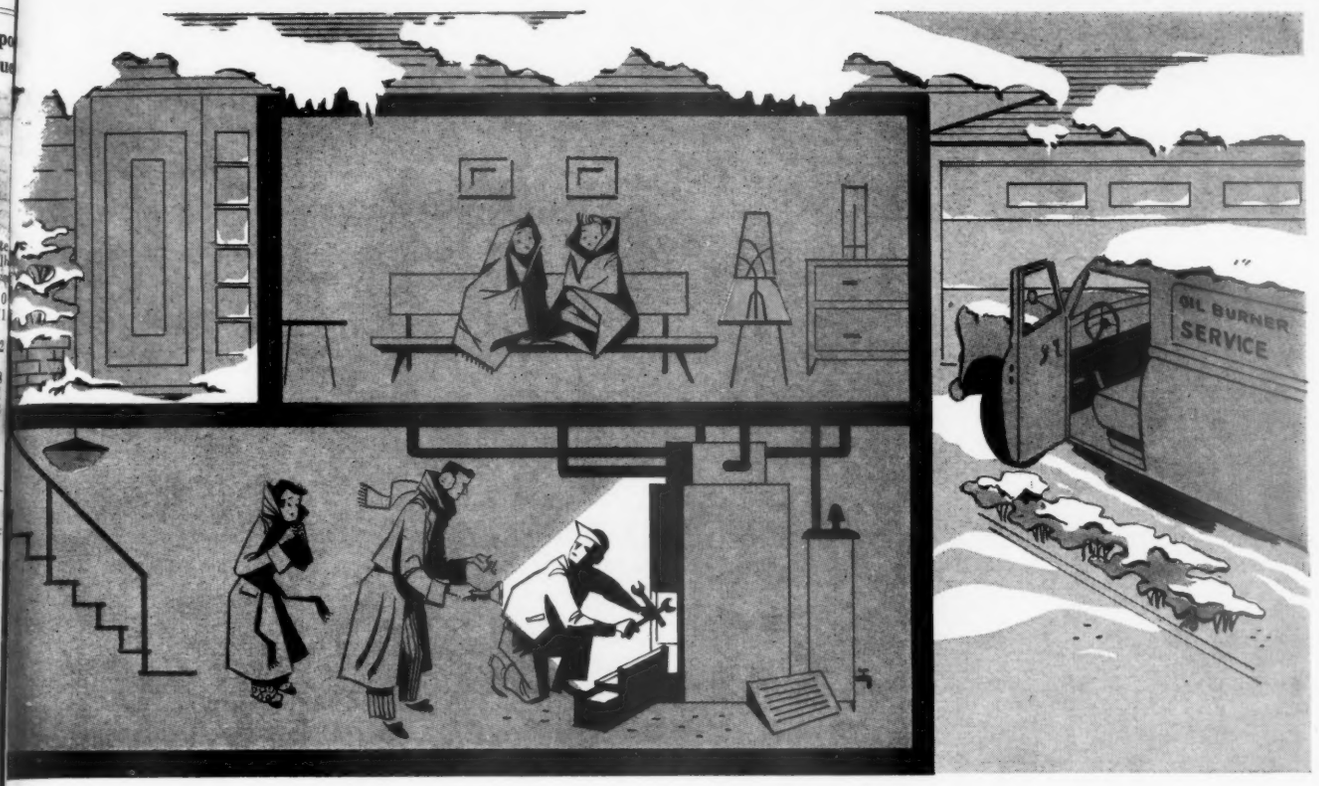
* Numbers refer to similar process vessels in Table 6.

indicates that corrosion should not be a significant problem as the calculated iron removal rates were very low. The pH values of the effluent water from the various vessels, however, might give the impression that a corrosive environment existed. This plant was shut down after 12 years of operation and visually inspected internally for corrosion. The findings agreed with the condition indicated by the iron removal rates, and the plant was returned to operation with no repairs. During these 12 years it was necessary to replace two 10-ft pipe sections between the still condensers and accumulators since leaks developed in an ell, and recently after 15 years operation, it was necessary to plug several tubes in the still reboiler. Such failures can hardly be classified as serious economical problems and are not contrary to the corrosion prediction scheme under consideration.

The data from plant "C," however, should not be interpreted to mean that all plants handling sour gas will not experience internal vessel corrosion, as the corrosiveness of the environment could easily change with variation in percentages of carbon dioxide and hydrogen sulfide in the gas as shown in Table 6 for plant "D" which has a high present carbon dioxide in the raw gas. One explanation for more corrosion in plant "D" than "C" is that the higher carbon dioxide partial pressure in the vessels of plant "D" could cause pH values low enough to dissolve iron sulfide films which otherwise might be protective.

Using the numbers beside the vessel names as references in Tables 5 and 6 it can be seen that vessel (3) is not subject to any particular corrosive action in plant "C," but that considerable iron is being removed from the same vessel in plant "D" which processes gas containing more carbon dioxide.

Plants pulling a vacuum on the gathering system could also experience a



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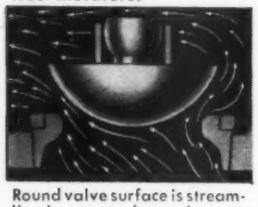

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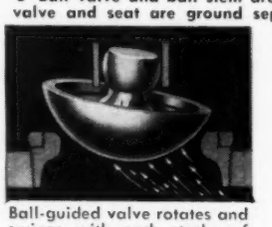

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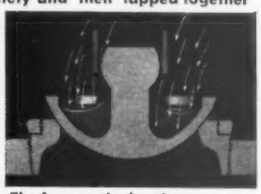

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TABLE 6. Summary of raw gas composition, iron content of effluent water, calculated iron removal rates and corrosion rates in Plant D.

Raw gas composition:
Carbon dioxide... 5.9%
Hydrogen sulfide. 0.6%

Critical pressures:
Absorber..... 200 psi
Still..... 110 psi

Vessel	Fe content of water in ppm	Iron removal rate rate in lb per year	Corrosion rate in mpy
(2)* High stage accumulator..	74	2	—
Lean oil surge tank bottoms	37	4	—
(1) Absorber bottoms.....	16	<1	—
(3) Hot stripper accumulator bottoms.....	11	515	25
(4) Cold stripper accumulator bottoms.....	15	3	—
(5) Still water leg bottoms....	13	75	13
(6) Still overhead reflux bottoms.....	30	93	19
(7) Raw gasoline accumulator bottoms.....	36	<1	—

* Numbers refer to similar process vessels in Table 5.

different environment if oxygen were allowed to enter the raw gas stream through leaks in the gathering system. Regardless of the combination of corrosive gases present in the process gas, however, these data and experiences indicate that iron removal rates and Audigage metal thickness surveys are effective methods for evaluating process vessel corrosion and determining the condition of process equipment after corrosion has occurred. Strategically located coupon exposure points, which are also helpful in corrosion studies, can be installed at the points suspected of corrosion during plant shutdowns, or with experience, can be installed at appropriate points during construction.

Acknowledgment

The author wishes to thank the officials of Shell Oil Company for permission to publish these data, and to acknowledge supporting information, obtained by numerous company engineers and chemists, which contributed a great deal to making this paper more complete. The author is also indebted to R. L. Rankin, Shell Oil Company, New York, New York, for his constructive suggestions, which were of great aid in preparing the article.

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* * *

REFINERY PLANTS SCHEDULED FOR COMPLETION

Commissioning of a new catalytic cracking unit is expected to increase petroleum production from Antwerp Refinery in Belgium. The new unit, jointly owned by British Petroleum and Petrofina, has a capacity of 500,000 tons a year.

★ ★ ★

Standard completes two refining units. Standard Oil Company of California has completed the two largest refining units in its $50,000,000 program to upgrade gasoline to meet the needs of higher compression engines in late-model automobiles. The twin facilities are catalytic reformers that have been placed on stream at Standard's Richmond and El Segundo refineries. New motor gasolines are being produced at a rate of more than 1,500,000 gal a day. Two additional catalytic reformers of lesser capacity are under construction at refineries operated by Standard subsidiaries at Vancouver, British Columbia, and El Paso, Texas.

★ ★ ★

Gilsonite processing plant planned. The American Gilsonite Company, owned jointly by the Barber Oil Corporation and Standard Oil Company of California, has announced plans to manufacture metallurgical coke and high-test gasoline from Utah's native Gilsonite deposits. The project calls for the expenditure of more than $10,000,000 to expand its Gilsonite mining operations at Bonanza, Utah, to construct a refining plant in Western Colorado, and to lay a connecting pipe line to supply raw material to the new plant.

★ ★ ★

Calspray builds new California lab. California Spray-Chemical Corporation has announced the construction of a new bio-screening laboratory in Richmond, California. The new lab is a part of the company's program for expanded research facilities and will be used to develop new, safer, and more effective Ortho pesticides for use by growers and gardeners throughout the world. Present plans for the new laboratory call for the complete remodeling of an old building located at Standard of California's Richmond refinery. Building in which the new lab will be housed was formerly used by the California Research and Development Corporation, which worked there on projects for the Atomic Energy Commission before the entire operation was moved to Livermore, California. The lab was expected to be in operation about the end of July. It will be staffed by about fifteen Calspray scientists.

★ ★ ★

Fluor to construct Ultraformer. The Fluor Corporation, Ltd., has been given a contract by the Utah Refinery Company to engineer and construct a 5500 bbl per day Ultraforming unit at the refinery in Salt Lake City. Engineering work has already begun and construction completion is scheduled for the first part of 1956.

★ ★ ★

Texas Company contract goes to Fluor. The Texas Company has awarded a contract to the Fluor Corporation, Ltd., to design, engineer and build a 4800 bbl per day UOP-type Unifiner-Platformer unit at Texaco's Casper, Wyoming, refinery. The unit will be used to process heavy straight run plus cracked naphthas. Engineering work is under way with completion expected early next spring.

★ ★ ★

New California ammonia plant. Ammonia Chemical Corporation of California will construct a $3,250,000 anhydrous ammonia plant in the Red Top district near Merced, California. The plant will process natural gas from nearby fields.

Southwestern Engineering awarded contract. Southwestern Engineering Company of Los Angeles, California, has a contract to build a 5000 bbl per day Platformer for the Anderson-Prichard Oil Corporation at its Arkansas City, Kansas, refinery.

★ ★ ★

New Canadian buildings. New administration and plant protection buildings costing $300,000 will be begun immediately by Canadian Oil Companies, Ltd., at Sarnia, Ontario. Administration building will be one-story, 144 ft long by 41 ft wide. Protection building will be one-story, 132 ft by 41 ft. About 80 per cent of the outside walls will be heat and glare-reducing panels.

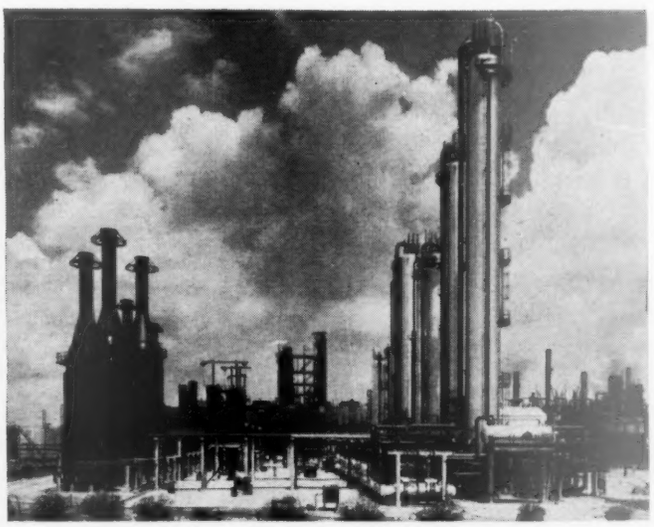
★ ★ ★

Ashland Oil & Refining plans expansion. Expansion of Ashland Oil & Refining Company's No. 2 refinery at Catlettsberg, Kentucky, has been announced. Plans call for increasing capacity by 20,000 bbl, to 55,000 to 58,000 bbl daily. Plant completion is expected by June, 1956.

★ ★ ★

New butane-splitter column. Lone Star Gas Company has installed a butane-splitter column at its gasoline plant at Springtown, Texas, in north Parker County that will step-up production of liquid hydrocarbons by some 8000 gal daily. Cost of the unit is estimated at $60,000. The butane splitter is planned to produce an estimated 6000 gal of isobutane and 15,000 gal of commercial butane daily. Installation of the butane-splitter column started in mid-May and was scheduled for completion by July 1. The work was carried by the regular plant construction crew at Springtown augmented by twelve men either hired or moved in from other Lone Star points.

Gulf Oil Corporation's new 29,000-bbl-per-day catalytic reformer, the largest ever built, has been placed "on the line" at the company's Port Arthur, Texas refinery.



Two Hydrofiners recently completed at Esso Bayway refinery, each refining a stream of cracked materials. One treats 7640 bbl per day of cracked naphtha; the other hydrogenates 19,520 bbl.

Sunray to operate new Texas plant. Sunray Mid-Continent Oil Company has been elected by an operators' committee to operate a new low-temperature, absorption-type gasoline plant with dehydration facilities to be built in Corpus Christi, Texas, by 13 oil and gas producers. The Red Fish Bay gas products plant is designed to process 140,000,000 cu ft of gas per day with 80 percent propane recovery. The total plant production will be approximately 125,000 gal of LPG and natural gasoline products per day, of which Sunray's interest will be approximately 30 per cent. New plant will be located near Ingleside, Texas, in San Patricio County about one mile north of the Red Fish Bay compressor station and high pressure gas delivery facilities operated by Sunray. Work on engineering phases of the plant has already started. Field construction should begin on September 1 and completion of the project is scheduled for February, 1956. The Dresser Engineering Company, Tulsa, Oklahoma, is to be the contractor on the $3,000,000 project.

★ ★ ★

New Kansas Ultraformer for Derby Refining. Derby Refining Company has announced that it will expand its Wichita, Kansas, refinery by adding a new Ultraforming Unit, the first to be built in the state of Kansas. The new unit is part of a $700,000 program designed to increase the refinery's capacity to produce high-octane gasolines to meet anticipated demands of high compression automobile engines. Capacity will be 2500 bbl, expandable to 4000 bbl. The Derby Ultraforming Unit is being constructed under a license from Standard Oil Company of Indiana that includes patent rights of Esso Research and Engineering Company. Unit will be built by J. F. Pritchard & Company of Kansas City, Missouri. It is scheduled for completion January 1, 1956.

★ ★ ★

New gas processing plant in Neches Woodbine. Construction of a gas processing plant in the Neches Woodbine field by Humble Oil and Refining Company was to begin July 1, after a delay from June 20. Location of the plant will be on a 33-acre tract in Cherokee County near Ironton, Texas. The plant is to have a capacity of 11,000,000 cu ft of gas and 53,000 gal of liquids daily.

★ ★ ★

Two H_2SO_4 units for Texas. Two sulfuric acid sludge plants were placed on stream recently, at Houston and at Baytown, Texas, to recover acid mainly from petroleum refinery sludge. Consolidated Chemical Industries own them; Chemical Construction Corporation built them; they will add 280,000 annual tons of sulfuric acid to the nation's supply. The sludge supplies heat for process, burned in a furnace, with only small quantities of "outside" fuel.

★ ★ ★

New Canadian catalyst plant. Work has started on the fluid catalyst manufacturing plant of Davison Chemical Company, Ltd., Canadian subsidiary of Davison Chemical Company at Valleyfield, near Montreal, Quebec. Plant will cost $6,000,000, is being architect-engineered by Badger division of Stone & Webster Engineering Corporation. Project manager is W. E. McLean, of Davison's central engineering department.

These Oxycats—part of a bed of 10,000 such catalytic elements at Sun Oil Company's Marcus Hook, Pennsylvania, refinery—digest carbon monoxide and hydrocarbon bearing gases exhausted from one of Sun's new Houdriflow petroleum cat crackers. Burning of these waste gases by the Oxycats—provides a high-temperature gas stream that generates 50,000 lb of steam an hour in boiler section.

Hydrogen for chemical company. A "high purity" hydrogen plant for Tennessee Eastman Company, is licensed by The Girdler Corporation at Kingsport, Tennessee, using the Hygirtol process, a steam-hydrocarbon decomposition process. Bays Mountain Construction Company will build it, to be completed by the first of 1956. Liquefied petroleum gases will be the raw material; catalysts include the G-29 nickel-base reforming catalyst. G-3 "promoted" iron carbon monoxide conversion catalyst, and the G-12 nickel-base methanation catalyst, and the G-32 activated carbon desulfurization catalyst.

★ ★ ★

Fluid coker for West Coast. World's largest fluid coker is under construction at the Avon, California, refinery of Tide Water Associated Oil Company. With a 42,000-bbl-per-day charge capacity, it is said to be 11 times the size of any other fluid coker now existing. It is being built by Bechtel Corporation, and should be completed by May, 1956. The unit will be 256 ft high.

Company also plans a 24,000-bbl-per-day hydrosulfurization unit, new gas plant and more service buildings, also enlargement of the fluid capacity cracking unit, all of which will increase the plant's capacity by 30 per cent; present capacity is more than 100,000 bbl per day.

★ ★ ★

British Petrochemicals. British Petroleum Chemicals, Ltd., has announced plans to spend more than £ 8,000,000 ($22,400,000) to expand and diversify its output of petrochemical products at Grangemouth, Scotland. The company is owned jointly by The British Petroleum Company, Ltd., and The Distillers Company, Ltd. Plans call for the construction of additional cracking and gas separating plants, a synthetic alcohol plant, and a new unit for the extraction of butadiene. In addition, a new unit will be erected at nearby Grange Chemicals, Ltd. (owned by British Petroleum Chemicals and Oronite Chemicals, a subsidiary of Standard Oil Company of California), for the production of detergent alkylate, which is used by the soap industry in the manufacture of synthetic detergents. Main contracts for the expansion have been placed with two U. S. companies, Stone & Webster Engineering Corporation, for the major extensions and Kellogg International Corporation for the butadiene plant will do most of the building. The new units are scheduled to be commissioned at various times between the last quarter of 1955 and the first half of 1957.

★ ★ ★

New UOP Platformer at Corpus Christi. A 9000-bbl per-stream-day UOP Platforming unit designed to produce 97 clear octane Platformate will be constructed at the refinery of Southwestern Oil and Refining Company in Corpus Christi, Texas. Construction of the new unit will begin immediately, and it is expected to be in operation early next year. The Platformer is being engineered, designed and licensed by Universal Oil Products Company.

★ ★ ★

Thompson Chemical to build PVC plant. Thompson Chemical Company will build a plant for the manufacture of polyvinyl chloride at North Dighton, Massachusetts. Scientific Design Company, Inc., New York City, has been engaged to design and engineer the plant. Thompson will use Scientific Design's suspension process of PVC resin manufacture. This method, in contrast with the more limited "emulsion" technique, produces a resin of great versatility which may be used for a wider variety of end products, particularly film, sheet, and extruded items.

★ ★ ★

New acid plant for Alabama. Consolidated Chemical Industries, Inc., has announced contract to Leonard Construction Company to build a 500-ton-per-day capacity contact sulfuric acid plant. Unit will be built on the Mobile River at Le Moyne, Alabama, 35 miles north of Mobile. Construction will include office building, machine shop, storage and shipping facilities, in addition to the plant itself. Work on the site is under way and is expected to be completed late in the second quarter of 1956.

★ ★ ★

Stanvac refinery to be modernized. A modernization program for Standard-Vacuum Oil Company's oldest and largest refinery—the Sungei Gerong plant near Palembang, Sumatra — has been announced.

Improvements will cost approximately $20,000,000 and take about two and one-half years to complete. They are part of the company's four-year $80,000,000 capital investment program in Indonesia.

Modernization will include: Installation of a 10,000 bbl-a-day recycle fluid catalytic cracking unit; installation of an 1100 bbl-a-day non-selective catalytic polymerization plant and revamping existing process equipment.

Another project included in Stanvac's current capital investment program in Indonesia is the building of a 90-mile pipe line to be completed in 1958, from the Lirik field to carry 20,000 bbl a day of crude oil. Coastal craft will be used to convey crude from the pipe line terminal to Sungei Gerong refinery. Already being installed are additional power generating facilities, and bids are being received for a new sulfuric acid plant.

REFINING AND PETROCHEMICAL

PERSONALS

G. C. Vergne

M. R. Schrein

Glenn C. Vergne of Concord, Calif., has been appointed safety engineer of Tide Water Associated Oil Company's Avon Flying A refinery here. Vergne succeeds **Samuel O. Bacon,** who has recently been promoted to safety engineer of the company's western division with headquarters in San Francisco. Vergne, who has been with the oil company here since 1934, was a foreman of the refinery's inspection department until his selection to be refinery safety engineer.

In connection with the recent merger of Universal Polychem Company, a wholly owned subsidiary of Universal Oil Products Company, into the parent company, UOP's board of directors elected **M. R. Schrein** as vice president of Universal with responsibility for manufacturing. Schrein was vice president and general manager of Universal Polychem. Also elected by the board were **Frank O. Byrne** and **Thomas B. Drake** as assistant secretaries of Universal; **D. A. Cameron** as comptroller of Universal, and **A. W. Lindahl** as assistant comptroller.

Promotion of **Sam R. Bethea** to research specialist in research and development division at Humble Oil & Refining Company's Baytown, Texas, refinery has been announced. He holds the BS and MS degrees in chemical engineering from The Rice Institute. In his new position, he will specialize in the development of new catalytic processes.

Charles E. Lapple, former associate professor of chemical engineering at Ohio State University, and **Rudolph H. Thielemann,** former development metallurgist for Pratt and Whitney Aircraft, have joined the chemical and metallurgical engineering section of Stanford Research Institute's physical sciences division. Lapple, as a senior scientist, will organize, coordinate and direct research activities in the fields of fine-particle technology and chemical engineering. Thieleman, as senior metallurgical engineer, will coordinate and supervise research in metallurgy projects at SRI.

Hubert C. Snowden is the new general superintendent of the Southern division, Consolidated Chemical Industries, Inc., one of the nation's major producers of sulfuric acid. He replaces **J. C. Crowder,** who moves to San Francisco headquarters as vice president and general manager in charge of West Coast and East Coast glue operations; **O. D. Massey** replaces Snowden as plant manager of the Houston plant; and **J. A. D. Todd** replaces Massey as plant manager of the Fort Worth plant.

Robert E. Howe, manager of the Sinclair, Wyoming, refinery since 1950, has been appointed assistant to the vice president in charge of manufacturing with headquarters at the New York office of Sinclair Refining Company. In his new post, he will be connected with both operations and adaptation of new processes to Sinclair refineries. Howe is currently vice chairman of the Military Petroleum Advisory Board of District four; a member of the API board of councillors, Rocky Mountain sub-group, and past chairman of the refining committee of the Rocky Mountain Oil & Gas Association.

E. H. Hausner is being promoted from assistant manager to take Howe's place as plant manager, and **Jack Corley,** formerly head of the technical department, is being promoted to assistant plant manager.

Dr. Lloyd H. Reyerson, colloid chemist and professor of chemistry in the University of Minnesota, has been named general chairman of the one-twenty-eighth national meeting of the American Chemical Society, which will be held in Minneapolis, September 11 through 16.

Dr. Charles Allen Thomas, president of the Monsanto Chemical Company, St. Louis, and a leader in the wartime atomic energy program, will receive the 1955 Priestley Medal, highest honor in American chemistry. The gold medal is conferred annually by the Society for "outstanding services to chemistry." The Priestley Medal address by Dr. Thomas will be followed by ACS President Joel H. Hildebrand's presidential address.

Frederick C. King has been appointed assistant to the manager of the Torrance refinery of General Petroleum Corporation., according to an announcement by **R. E. Lauterbach,** manager of manufacturing. **W. R. (Doc) Goddard,** assistant to manager of the Torrance refinery, will retire August 1 upon completion of 36 years service with the company.

Ernest E. Lyder has been elected president of U. S. Oil & Refining Company, Los Angeles. Dr. Lyder was formerly general manager of the El Segundo refinery of Standard Oil Company of California. U. S. Oil & Refining, successor to Pacific Oil & Refining Company, is building a $10,000,000 refinery at Tacoma, Washington.

Lonnie W. Vernon and **E. L. Gunn** have been promoted to senior research chemists, research and development division of Humble Oil & Refining Company at Baytown, Texas, refinery. Dr. Vernon will assume principal responsibility for Humble's catalyst property research. He holds a BA and an MA in chemistry, and PhD in physical chemistry from Rice Institute.

Gunn's research is in the fields of emission spectroscopy, X-ray diffraction and X-ray fluorescence. He holds a BA in chemistry and an MA degree in psychology from The University of Texas.

Dr. Norman A. Shepard has retired as chemical director of American Cyanamid Company. During his 42-year career in the chemical industry, he became widely known in industrial, governmental and academic circles. He began his career in 1913 as an instructor in chemistry at Yale University, became assistant professor four years later, and in 1919 joined Firestone Tire and Rubber Company as director of organic chemical research. In 1925 he was named director of chemical research.

Dr. Shepard joined Cyanamid in 1936 as director of technical service and was named to his most recent post in 1941. He has served on numerous scientific and technical bodies of the government, universities and industrial associations. He is now serving the Department of Defense as a member of the materials panel in the office of the assistant secretary of research and development; he is director and assistant treasurer of the Council for Agriculture and Chemurgic Research, and a member of its research committee; a member of the advisory committee on chemicals for the director of the Bureau of Standards; a member of the advisory committee on plastics of Princeton University's School of Engineering; a member of the Engineering Manpower Committees of the American Chemical Society and the American Institute of Chemists; a trustee of the Dorr Foundation and chairman of the board of the Dorr Company Educational Trust. He was graduated from Yale University.

Ed L. Raun, process superintendent at Tide Water Associated Oil Company's Bayonne refinery, has been selected by the company to attend Cornell University's special summer executive development program. Raun, who has been with the company since 1934, is one of 25 executives chosen from companies throughout the country to further their studies in management techniques.

New officers of the California Natural Gasoline Association for the fiscal year 1955-1956 are **C. L. Case,** Continental Oil Company, superintendent of gasoline operations at Ventura, president, and **Raymond W. Todd,** Pacific Lighting Gas Supply Company, vice president. New members of the board of directors are **E. C. Cunningham,** Wilmington Gasoline Company; **D. W. Darnell,** The Fluor Corporation, Ltd; **M. L. Fort,** Pacific Lighting Gas Supply Company; **C. D. Gard,** Union Oil Company of California; **R. W. Heath,** Signal Oil and Gas Company; **J. C. Herron,** Shell Oil Company; **B. N. Howell,** C. F. Braun and Company; **Lloyd Jones,** The Cooper-Bessemer Corporation; **William A. Kirk,** California Southern Oil Company; **Warren H. Kraft,** Honolulu Oil Corporation; **Grove Lawrence,** Southern California Gas Company; **L. V. Leonard,** Shell Oil Company; **A. C. Lyles,** General Petroleum Corporation; **S. F. Magor,** The Superior Oil Company; **P. S. Magruder,** General Petroleum Corporation; **J. A. Smith,** The Texas Company; **K. C. Vaughan,** Union Oil Company of California; **E. W. Walker,** Western Gulf Oil Company; **A. H. Weil,** United Gas Pipeline Company; and **L. W. Windle,** Richfield Oil Corporation.

Joseph G. Davidson, vice president of Union Carbide and Carbon Corporation, New York, has been chosen to receive the Chemical Industry Medal for 1955 "for conspicuous services to applied chemistry." Announcement of the award was made by the American Section of the Society of Chemical Industry, donor of the medal. Dr. Davidson is recognized for research, production, and administration in synthetic organic chemistry, particularly for his vital part in creating and bringing to its present vast dimensions what is now known as the petrochemical industry.

Dr. J. G. Davidson

He is an alumnus of University of Southern California (BA, 1911 and MA, 1912) and of Columbia University (PhD 1918). Among his many awards, he was elected Honorary Fellow of the Royal Society of Edinburgh in 1954 and received a special award that same year from the Society of the Plastics Industry "for his inspired leadership and faith in the development of vinyl plastics." In April 1955 the University of Southern California, his own Alma Mater, awarded him the honorary degree of Doctor of Science. He is a member of the American Chemical Society and was chairman of its New York Section in 1930.

Five changes in The Texas Company's research and technical department have been announced. They include **Harry Levin,** promoted to assistant to the manager, research division, Beacon, New York; **B. Y. McCarty,** who succeeds **Claude Emmons,** retired as regional manager, Los Angeles; **J. E. Rosnell,** who succeeds McCarty as regional manager, Chicago; **R. S. Barnett,** promoted to technical service associate, technical service administration, Beacon Laboratories, and **F. M. Roberts,** who succeeds Levin as supervisor, analytical and testing department.

J. W. Hopkinson, president of Penn-Petroleum Corporation, Detroit, Mich., is new president of the American Society of Lubrication Engineers, elected recently. **W. Deutsch** of the Trabon Corporation was elected vice president at large; **E. R. Booser,** General Electric Company is secretary, and **W. H. Fowler, Jr.,** of Pure Oil Company, is treasurer.

Regional vice presidents include **G. R. Armstrong,** Canadian, with B. Greening Wire Company, Ltd; **E. D. Harkins, Sr.,** Midwestern, Farval Corporation; **J. O. McLean,** Eastern, Reynolds Metals Company, and **M. H. Sperling,** Western, of Richfield Oil Corporation.

Directors are: **J. H. Fuller,** E. I du Pont de Nemours and Company., Inc., **J. D. Lykins,** Wheeling Steel Corporation, **W. H. Millett,** Carbide and Carbon Chemical Company; **A. E. Roach,** Research Laboratories division, General Motors Corporation, and **C. R. Schmitt,** E. F. Houghton & Company.

M. S. Metz has been named manager of Shell Oil Company's Houston area exploration department. He replaces **Sherwood Buckstaff,** who has been assigned to the company's head office exploration staff in New York. Buckstaff will remain in Houston, however, on special assignment. Metz joined Shell in 1937 as a junior geologist at Houston. He held various exploration and geological positions in Houston and San Antonio before becoming district geologist in the latter city in 1942. He became senior geologist in Shell's Midland area in 1946, and in 1949 was named area geologist and then manager of the exploration department in Calgary, Canada. He returned to Midland as area exploration manager in 1951 and has held that position until the present reassignment. A vetern of 30 years with Shell, Buckstaff has been manager of the company's Houston area exploration department since 1948.

Ben H. Loper was named Chicago sales representative, **C. O. Brown, Jr.** was appointed New York sales representative and **Reed Larson** was appointed assistant to the department's technical director in the refinery chemicals department of American Cyanamid Company's industrial chemical division.

Loper was associated with Reynolds Metals Corporation previous to joining Cyanamid in 1950 as a chemical engineer. He is a graduate of the Illinois Institute of Technology. Brown joined Cyanamid in 1949 as a chemical engineer. He is a graduate of Cornell University.

Larson will act as liaison between departmental research, development, production and sales functions. He is a graduate of Yale University.

C. F. Koch, formerly district superintendent of Magnolia's natural gas district at Wewoka, Oklahoma, has been transferred to Pampa, Texas, as district superintendent of the Panhandle district.

R. L. Argus

J. M. Brown

R. L. Argus, has been named assistant manager, Destrehan Refinery; and **John M. Brown,** assistant manager, El Dorado refinery, of Pan-Am Southern Corporation Refineries, El Dorado, Arkansas and Destrehan, Louisiana.

Mr. Brown joined the company in 1925 as a stillman, was named assistant superintendent in 1929 and in 1951 was promoted to assistant manger-operations. He attended Arkansas State Teachers' College at Conway, Arkansas.

John Horn, for several years representative for Phillips Petroleum Company's natural gas department in Houston, Texas, has been promoted to technical advisor to the department management in the Bartlesville office. He succeeds **Allen B. Hiatt,** resigned. **J. W. Mims,** formerly Horn's assistant, will succeed him as Houston representative.

Jon Thomas Moss has been promoted to senior research chemical engineer at the field research laboratories of Magnolia Petroleum Company, Dallas, Texas. Moss, a graduate of Texas A & M, joined the production research division at Magnolia's laboratories in 1952 and has been engaged in development work on the In-Situ Combustion Oil Recovery Process.

John Anderson, formerly research director at Shell Chemical Corporation's Houston laboratory, will be research director at the firm's new Torrance, California, laboratory, where studies will be conducted on synthetic rubber and allied materials. **D. S. Melstrom,** head of the organic section of the Houston lab, will head the chemistry section at Torrance. **F. D. Moss,** supervisor of the experimental plants department of Shell Development Company, Emeryville, California, laboratory will be head of the process and pilot plant section.

E. T. Bishop, of Shell Development, Emeryville organic and applications department, will be in charge of the product section at Torrance. **L. R. Beason,** research chemist of the company's organic section at Houston, will be a group leader in the new chemical section at Torrance. **W. L. Holmes,** research technologist at Houston, will be group leader in the process and plant section.

V. L. Keldsen, formerly manager of the production department in the ammonia division at San Francisco, California, will fill the newly established position of section leader, synthetic rubber, in the manufacturing development department. Keldsen will transfer to the home office in New York City. **Russell L. Maycock** has been appointed director of Shell Chemical's Houston research laboratory. Maycock has been assistant manager of the physical chemistry department at Shell Development Company's Emeryville research center. He will replace Anderson, who was named director of the Torrance lab.

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FIG. 29
Cylinder with Impeller

FIG. 17-28
Cylinder

FIG. 215
Flanged

FIG. E-57
Double Window

FIG. 212
Visibility Welding Neck or Screw

FIG. E-811
Flapper

FIG. E-1810
Rotating Wheel Type

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PIPE LINE DEVELOPMENTS

★ ★ ★

Roundup of Current Planned and Proposed Construction

NAME OF COMPANY	MILES	PIPE SIZE	LOCATION
CRUDE LINES			
Ar-Mex Pipeline Co.	790	12-14	Guernsey, Wyoming to Coolidge, Arizona
Big Horn Pipe Line Company	150	8	Ash Creek field to Midwest station of Service Pipe Line, Wyoming
Buckeye Pipe Line Co.	14	10	Wayne to Detroit, Michigan
Kaybee Pipe Line Company	46	10	Griffith, Indiana, to New Buffalo, Michigan
Malco Pipe Line Co.	40	4	Bloomfield, New Mexico to Rio Arriba county fields, New Mexico
Michi, Inc.	222	10	Highland, Indiana, to Elsie and Alma, Michigan
NNCW Pipe Line Co.	127	8-10	Weston County to Casper, Wyoming
Orchard Pipe Line	45	8	Orchard to Merino, Colorado
Pasotex Pipe Line Co.	70	20	Loop on present Wink to El Paso system, replacing twin 8-in. lines
Powder River Pipe Line Company	436	10-16	Williston Basin to Laurel and Billings, Montana
Proven Oil & Refining Company	32	8	Connection with West Coast Pipe Line to Florence, Ariz.
Roosevelt Oil & Refining Corp.	22	4.6	St. Helen to Norwick, Michigan
Salt Lake Pipe Line Co.	82	10	Loop on present 182-mile system between Rangley, Colorado, and Salt Lake City, Utah
Stanmount Pipe Line Co.	140	10	Beaver Lake field, North Dakota, to connection with Interprovincial Pipe Line
West Coast Pipe Line Company	960	20-22	Wink, Texas, to Norwalk, California
Union Oil Co.	815	—	Rifle, Colo. to Los Angeles, Calif.
U. S. Department of Defense	97	—	Crude line from Elk Hills Naval Reserve to Los Angeles, California
PRODUCTS LINES			
American Pipe Line Company	1910	8 to 26	Beaumont, Texas, to Newark, New Jersey, with laterals
Ar-Mex Pipe Line Company	130	8	Tucson to Coolidge to Phoenix, Arizona
H. W. Bass & Sons, Incorporated	152	4-6	Duval and Live Oak counties, Texas, to Corpus Christi, Texas
Bell Oil and Gas Company	140	6-8	Ardmore to Cushing, Oklahoma
Bowen Oil and Management Company (LPG Line)	460	10	Midland to Texas City, Texas
Buckeye Pipe Line Co.	60	8	Lima, Ohio to Ft. Wayne, Indiana
California-Oregon Pipe Line System	103	6	Crescent City, California, to Medford, Oregon
Deep Rock Gas Company (LPG Line)	120	6	Tioga, North Dakota to U. S. Canadian Border
El Paso Natural Gas Co. (LPG Line)	119	3-6	Bloomington to Gallup, New Mexico
International Pipe Line Inc.	132	8	Wrenshall to Minneapolis, Minnesota
Keystone Pipe Line Company	48	8	Boot Station to Fullerton, Pennsylvania
Malco Pipeline, Inc.	91	6	Prewitt to Albuquerque, New Mexico
Mayflower Pipe Line Company	400	10	New Jersey refineries to New England points
Moore-Stoner Company	200	6	Glendive, Montana, to Minot, North Dakota
Phillips Petroleum Company	50	—	Ethylene line from Sweeny to Pasadena, Texas
Shamrock Pipe Line Corp.	100	6	Amarillo to Abernathy, Texas
Sioux Oil Company	50	6	Newcastle, Wyoming, to Rapid City, South Dakota
Sunflower Pipe Line Company (LPG Line)	265	3-6	Kearny, Grant and Haskell counties to Wichita, Kansas
Texas Eastern Transmission Corporation	—	—	Will convert the "Little Inch" to products pipe line operation upon completion of new 30-in. gas line from near Beaumont to Kosciusko, Mississippi
Winnipeg & Central Gas Co. (LPG Line)	330	6	Tioga, N. D., to Winnipeg
GAS LINES			
Alabama-Tennessee Natural Gas Co.	21	12	Line in Colbert County, Alabama
Alberta Gas Trunkline	315	18-36	Gas Gathering System in Alberta fields
Arkansas-Louisiana Gas Company	136	8 to 24	Loops on System
Canadian-Western Natural Gas Co.	59	—	Line in Southern Alberta
Carolina Natural Gas Corp.	185	2-12	Laterals in North and South Carolinas
Central Hudson Gas & Electric Corporation	48	12	Albany to Kingston, New York
Cities Service Gas Co.	145	—	Gathering systems in Woods County, Okla., Barber County, Kans.
Coastal Transmission Corporation (c/o Delhi Oil, Dallas)	400	30	McAllen to Beaumont, Texas
Colorado Interstate Gas Company	110	6-8	Julesburg area to Denver Colorado
Colorado-Western Pipe Line Co.	328	16-18	Ignacio field to Pueblo and Denver
Colorado-Wyoming Gas Co.	20	4-16	Lines in Denver, Colorado, area
East Ohio Gas Co.	112	30	Maumee, Ohio, to Cleveland
El Paso Natural Gas Co.	370	—	Mountain Home, Idaho, to Reno, Nevada
El Paso Natural Gas Co.	74	—	Additions to Permian Basin-San Juan Basin system
El Paso Natural Gas	500	30	Loop of present San Juan-California border system
Houston, Texas, Gas & Oil Co.	600	30	Baton Rouge, La., to Miami, Fla.
Houston, Texas, Gas & Oil Co.	350	18-24	Baton Rouge to Miami
Kansas-Nebraska Natural Gas Company	206	6-12	Additions to Nebraska system
Lone Star Gas Co.	230	30	Cotton County Oklahoma, to Fritch, Texas
Lone Star Gas Co.	205	24	Snyder, Texas to connect with Cotton-Fritch line also proposed
Manufacturers Gas, Light & Heat	40	—	Allegheny, Washington, and Beaver counties, Pa.
Manufacturers Gas, Light & Heat	213	3 to 26	Various points on system in Pa., W. Va. and Ohio
Manufacturers Gas, Light & Heat	72	16-20	Doddridge, Wetzel and Marshall counties, West Va.
Michigan-Wisconsin Pipe Line Company	252	4-24	Loops and stations in Illinois
Mississippi River Fuel Corporation	190	10-18	Laterals in Woodlawn and Waskom gas fields, Texas
Morganfield Natural Gas	31	4-6	Through Sturgis, Providence, Clay, Diamond, Wheatcroft and Sullivan, Kentucky
Natural Gas Pipe Line Co. of America	350	20-26	Amarillo to Wise County, Texas
Natural Gas Producer, Inc.	100	12	Yenter pool to Denver, Colorado
Natural Gas Producer, Inc.	61	4-10	Northeast Colorado lines
Nevada Natural Gas Co.	114	—	Loop of present system
North Canadian Oils, Ltd.	136	10	Wabuman to Hinton, Alberta
Northern Natural Gas Co.	188	24	Canadian border to Wahpeton, North Dakota
Northern Natural Gas Co.	215	30	Wahpeton to Farminton, Minnesota
Northern Natural Gas Co.	94	12	Sioux Falls to Watertown, South Dakota
Northern Natural Gas Co.	71	10	Watertown to Duluth-Superior, Wisconsin
Northern Natural Gas Co.	167	24	Farminton to Duluth-Superior
Northwest Utilities Ltd.	42	—	Bonnie Glen to Edmonton, Alberta, Canada
Pacific Gas & Electric Co.	190	34	Topock, Ariz., to Milpitas, Calif.
Pacific Northwest Pipeline Corp.	380		Laterals and spurs off main line to Pocatello, Idaho, to Yakima, Washington
Panhandle Eastern Pipe Line Company	58	16	Peoria to Springfield, Illinois
Pine Tree Natural Gas Co.	204	—	Boston to Banger, Maine
Shenandoah Gas Company	39	3-4-8	Middleton, Virginia, to Martinsburg, West Va.
South Alberta Pipe Line, Ltd.	46	10	Etzikom field to Medicine Hat, Alberta
Southern Natural Gas Co.	50	—	Loop lines and add 4950-hp on system facilities in Georgia and Louisiana
Tennessee Gas Transmission Co.	221	26 & 30	Loops in Ohio and Kentucky
Tennessee Gas Transmission Co.	376	6-24	Gathering lines in Louisiana and Texas
Texas Gas Transmission	198	—	Loops and 20,270-hp to be added in 1956
Texas Gas Transmission Corp.	50	30	Bastrop, La., to Clarksdale, Miss.
Texas Gas Transmission Corp.	105	20	Eunice to Morgan City, La.
Trans-Canada Pipe Lines, Ltd.	2247	14-34	Alberta area to Toronto, Montreal
Union Gas Company of Canada	180	—	Dawn Storage field to Hamilton
United Gas Pipe Line Co.	63	16-20	New lines in Mississippi, Alabama, and Florida
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania
Utah Natural Gas Company	40	16	Orem to Salt Lake City, Utah
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Va.
Washington Gas Light Co.	11	24	District of Columbia to Gordon's Corner, Maryland
Westcoast Transmission Co., Ltd.	650	30	Peace River area, Alberta, to U. S.-Canadian border

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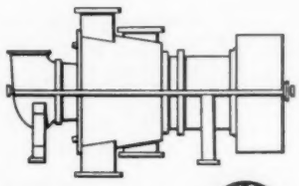

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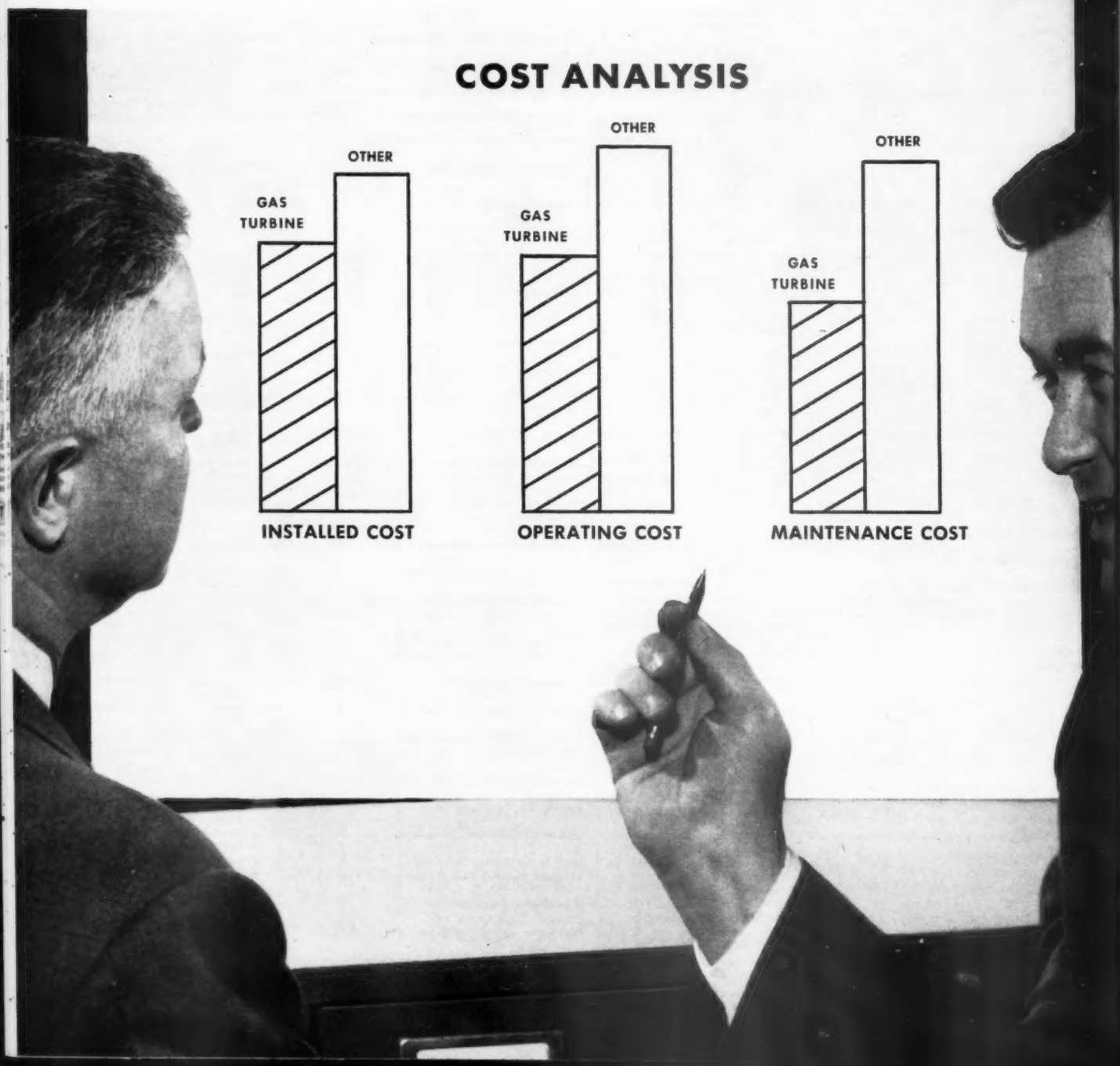
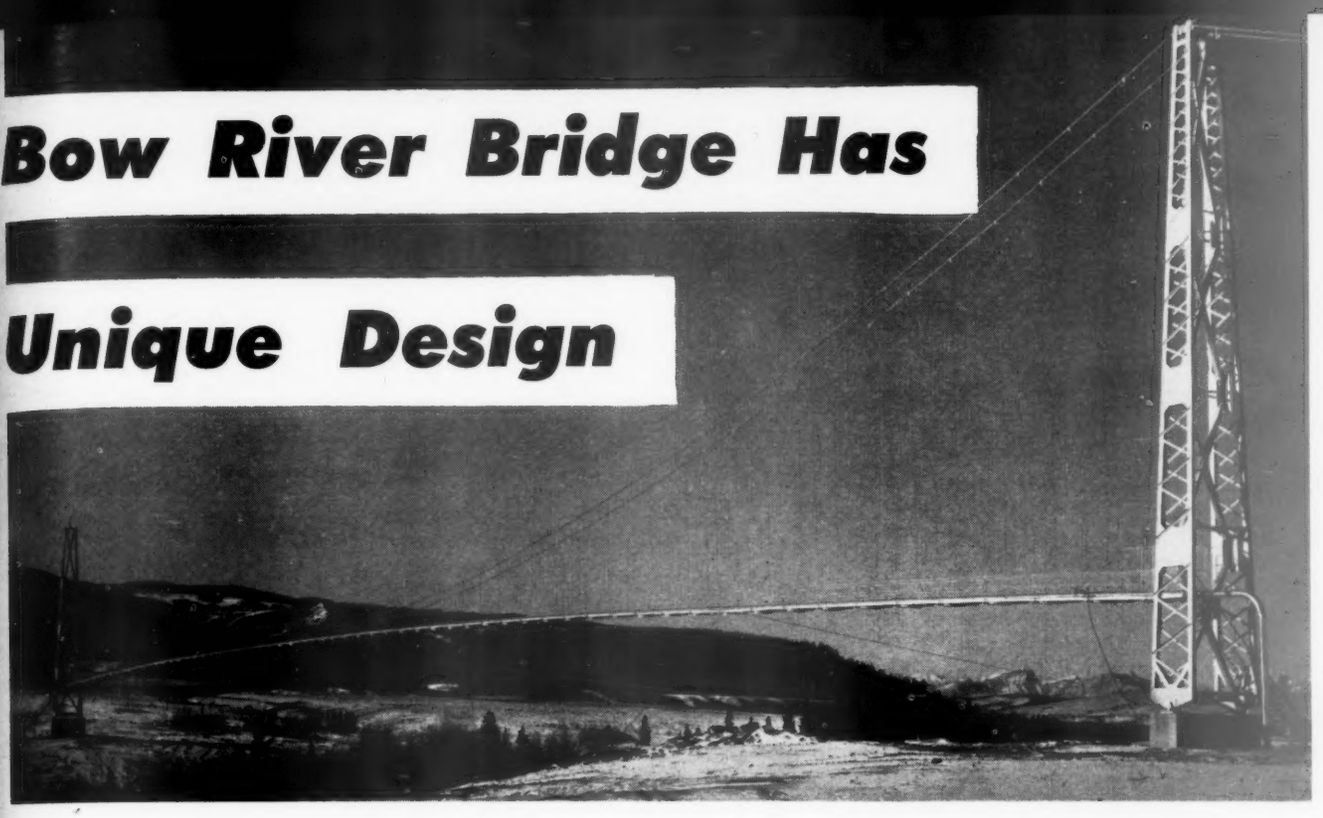


Bow River Bridge Has Unique Design



EXCLUSIVE

P 615.38

Suspension span over rugged Bow River in Western Canada to carry 8-in. gas line has many unusual engineering features

L. O. Rowland

A SPAN of 655 ft, believed to be the longest in Canada for its type of construction and application, is covered by a recently completed pipe line suspension bridge across the fast flowing Bow River west of Calgary, Alberta. The bridge supports an 8-in. pipe line transporting natural gas from Shell Oil Company's Jumping Pound Unit 13 and Unit 14 wells to the company's sulfur extraction plant situated on the opposite side of the river. The bridge is 75 ft above the water at the highest point of its bow. It was designed in Calgary by Jack Abugov, consulting engineer, and built by Hector Machine Company Ltd., Calgary. Construction time was approximately four months.

The basic design of the bridge was for a prefabricated, welded structure to be erected completely from shop-built sections before the pipe was to be strung across it. Thus, instead of using the pipe itself as the main backbone of the bridge, the bridge would provide a catwalk support across which the pipe could be strung without requiring the use of heavy equipment for either bridge or pipe.

The bridge was constructed of two welded steel towers mounted on rocker beams set in large concrete piers that virtually are cantilever beams. The catwalk was suspended from heavy steel cables that pass over the tops of the towers and are anchored by steel rods set in concrete blocks in the ground behind the towers.

Piers and Foundations

The tower foundations were poured of concrete. On one side of the Bow River, where a solid rock cliff juts out 50 ft above the water, the foundation pier extends 5 ft above grade, while on the other side, where the soil is uncompacted pea gravel, the pier rises 8 ft above grade. Both piers are set 17½ ft below grade, with cantilevered footings extending out several feet on all sides. Continuous poured concrete was mixed on the site; 110 yds were used on the high pier and 90 yds on the lower one.

The piers were designed essentially as cantilever beams, which minimize the effect of lateral support from the ground and depend for their stability on the weight of the ground resting on their vertical faces and on the cantilever bottom. This provides the necessary support against the possibility of overturning with the sway of the towers.

In the actual design, the lateral ground factor was ignored as a further safety measure. Slab weight and ground pressure on the slab were calculated as a combined force to act as a full cantilever from 15 ft below the ground. Abugov calculated that the towers could be sustained with no help from lateral ground support, without prejudice to their stability. Each tower is 105 ft high and weighs 15 tons.

Unique Tower Design

The tower design is extremely original. In effect, each tower is a composite I-beam built of smaller I-beams. It consists of steel columns of 8-in. by 8-in., 35 lb wide-flange I-beam. The bottom of each main member is 6 ft wide, with this spread tapering to only 2 ft at the top.

The two main members, which constitute the ends of the towers, are joined by steel lattice-work of angle iron. These broad sides also taper, from

XUM

a 12-ft spread at the bottom to 5 ft at the top. They are wind-braced with wide-flange beams notched into and welded to gusset plates.

The double taper, understood to be a unique feature never before incorporated into a similar structure, was designed to meet the problem of side wind pressure, which would exert a compression of 170,000 lb on the leeward leg of the tower if no lateral support from the guy wires were to be considered.

Erection of Bridge

The towers were the first items to be erected. Shop-welded into single units, they were transported to the job site by two trucks each. The trucks were hitched up back-to-back. The driver of the second truck steered his vehicle from the running board without mishap. Each of the 30-mile trips took five hours. A crew of only four men was required for this job, as for the erection of the rest of the bridge structure. In a matter of four hours, each tower was raised by a 75-ft gin pole, rigged up as a temporary measure, and secured by temporary rigging.

The cables were then strung between the towers, the most troublesome feature of the entire construction. The total length of each cable is 1120 ft, while the clear span between the towers is 655 ft. The cable sag in this distance is 65 ft, so that a net addition of almost three per cent, or 17 feet, more cable than the horizontal distance between towers had to be included in the calculation. The rocker design provided more effectively than would any alternate design for the expansion and contraction of the 1120 ft of cable.

Each main cable was made up as a paired 1½-in. twin cable, providing easier handling and considerably more ease of handling than would a single 2¼-in. cable, which would have the same bearing strength.

Cable stringing was speeded by the stringing of a temporary high line across the river between the towers. From this first line, two high lines were strung to handle the cables on the two sides of the bridge. The main cable was fastened to the high line on each side, with the two cable units in each case being fastened alternately at regular intervals. This prevented any risk of the cable twisting back into its original loop as imposed by winding on the shipping drum while it was being strung.

The cables were fed off the shipping spools on the river bank and joined in their pairs by yoke clamps. Suspenders, hung from the yoke clamps, were added on 10-ft centers. Each suspender was designed to be a straight dead-load support that will carry the complete weight of a 10-ft section of the bridge. Construction was of ⅜-in. regular galvanized cable. At all points to which guy wires were to be attached (for lateral support against swaying), heavier ⅝-in. suspenders were used to carry the additional vertical reaction added by the tension of the guy lines. The suspenders consist of an eyebolt, cable, and thimble, calculated mathematically to a tolerance of ⅛-in. and precut.

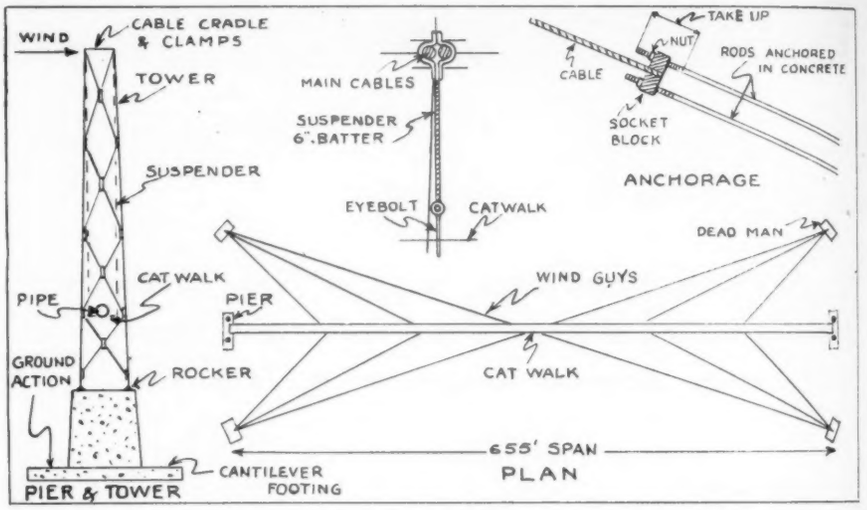
With the suspenders attached, the main cables were fed across the river on the high lines until the main anchors were reached. There they were socketed into turnbuckle blocks. With the thrust taken up, the cables were then raised vertically by the temporary gin poles, which were mounted on the tower tops, and were hoisted over the tops, where they were seated in cradle blocks and clamped down with six clamps on each tower. A single side-bracing. This provides lateral rigidity, while also providing for vertical and lengthwise movement due to temperature. At the same time, it maintains complete rigidity sideways. The sections were joined by double pins, one fixed and one moving in a crescent slot. The width of 4 ft provided plenty of working space to pull the pipe.

Pipe Installation

Pipe was made up and welded on the river bank on one side and pulled across after all the structural work except guard rails had been completed. One tractor with a sideboom was used for pulling from the opposite side. The pipe was carried on dollies constructed of flanged coupling, one dolly carrying the weight of each 40-ft joint.

The pipe was extra-heavy, river crossing type, 5⅝-in. wall thickness. Every weld was X-rayed, and the entire pull took nearly three days. It was pulled bare and when in place was wrapped with a 2-in. glass fiber and an aluminum foil outer wrap. The glass fiber was made up as half-round performed blocks. Both it and the outer wrap were banded on individually.

The only point of attachment of the pipe is in the center. It is given a "floating ride" on wood blocks, which were placed at 10-ft centers directly beneath steel cross braces held by the suspenders. Thus, in effect, the main cable, and not the catwalk, takes the bulk of the pipe weight. The only points at which the catwalk bears any weight of the pipe are at the points of suspension. The pipe load is transmitted through the wood blocks to the cross beams and thence directly to the suspenders. * * *

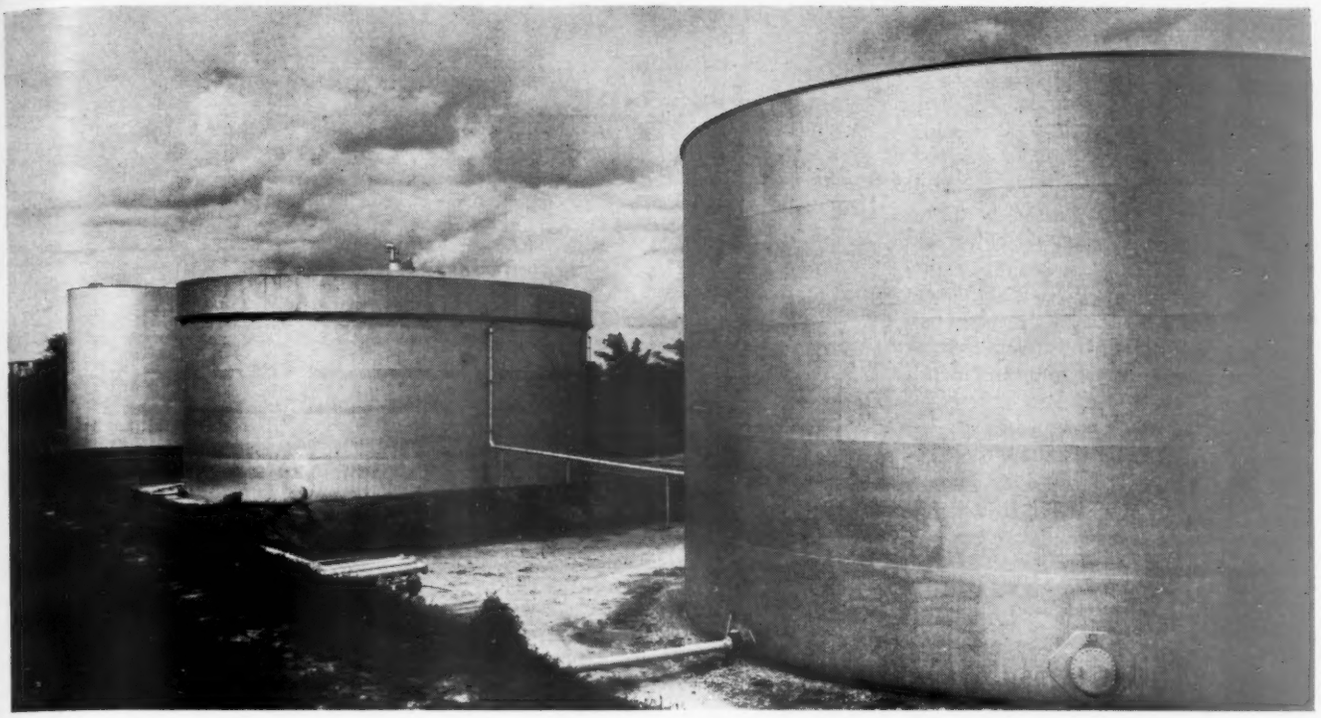


Construction and design details of the bridge. Diagram shows features of piers and towers, pier layout, catwalk and wind guy lines, attachment of main cables to each suspender and of suspenders to the catwalks, and connection between main cable and its anchorage at each end with arrangement of takeup threads and nuts.

boom tractor was used to take the weight of each cable as it was being lifted into position to be hooked onto the high line with a snatch block. The total stretch of the cables is estimated at 4 ft in each 1000 ft.

Walk Structure Provided

The walk structure was installed after the cables with the suspenders were in place. Working both ways from the center of the span, the crew slid together 10-ft prefabricated steel sections of expanded metal mesh designed for regular loading. Each section, 4 ft wide, weighs 400 lb. The main cables will carry standard snow and ice loads, 27,000 lb of pipe, and the dead load of the whole superstructure. The frame for the walk sections is of 5-in. channel iron with cross



Here's how Sinclair handles the selection, maintenance and retirement of

Oil Storage Tanks

C. V. Lynn
Sinclair Refining Company,
New York, New York

PROBABLY three-fourths of Sinclair's total refinery properties are occupied by facilities for storing and handling liquid products. A simple addition of refinery tank lists indicates a grand total of over 26,000,000 bbl gross storage capacity, and this is being continually increased. The replacement cost of this tankage and the value of the real estate, foundations, dyke walls, and auxiliary equipment all amount to a tremendous capital investment, while the value of the stored products may be much greater.

Aside from the more or less fixed charges for interest, insurance, and taxes, the annual expense of maintaining these facilities and protecting products against loss is subject to some control. Therefore, economies that can be effected by proper selection, sound construction, efficient maintenance, and timely retirement of tankage, are vital factors in operating costs.

Although the scope of this article is limited to those factors bearing upon reduced annual expense, a brief review of some of the elements of design and construction is pertinent since we are concerned with over-all economy that also involves the integrity of structures and the safety of investment.

Design and Construction

Throughout the industry, the basic code used for the design of welded oil storage tanks is API Standard 12-C. There are also standard design codes for light welded production tanks, riveted tanks, and bolted tanks, but API 12-C tanks are generally purchased by the refineries and pipe line companies. These specifications are constantly being revised to keep them up-to-date with new developments.

Sinclair's general specifications and those which are used for individual tank purchases are based upon API 12-C with a few elaborations and alternates to suit particular requirements. The specifications are likewise periodically revised to reflect the results of experience and current thinking.

While storage tanks are big, simple appearing structures, a considerable amount of engineering thought and manufacturing technique has gone into their development in order to make them efficient and safe, and it must be remembered that they have their limits of abuse.

The unit stresses utilized in design exceed those used for carbon steel pressure vessels. The materials used are not as select. There is seldom any allowance for corrosion. The inspection and testing procedures are not as rigid. The safety factor is considerably less, yet the consequences of failure of a large tank could be just as disasterous as the failure of a pressure vessel.

While there have been no serious failures of tanks built in the United States and strictly in accord with API

12-C specifications, some tank failures abroad, failures of welded ships, and recent studies of the phenomenon of brittle fracture and notch sensitivity have emphasized the need for extreme care in some of the details of construction and repair and the importance of thorough inspection. Although the integrity and skill of the fabricator and erector are the most important factors in the quality of a job, it is suggested that the purchaser has some responsibility and should furnish competent inspection of his own or some independent agency.

Revised API standards and our own Sinclair specifications will reflect the results of some of this study in certain restrictions on materials; a little closer attention to fabrication details; provisions for non-destructive tests, such as random radiography and magnetic particle testing, and some recommendations relative to tank foundations. It becomes increasingly apparent that considerable more care should be used in making repairs and field installations of appurtenances.

This seems an appropriate place to emphasize the need for better tank foundations and grades. Many older tanks are bogged down in mud holes where bottom shell rings are being damaged by corrosion.

It is impossible to keep this area painted, and the service life is being shortened. Storage tanks should have a suitable concrete foundation with a sand or gravel fill. The foundations should be at least one foot above the surrounding grade to keep the tank out of the mud and to provide a dry bottom. The grade must be well compacted and crowned to compensate for some settlement and to facilitate cleaning. There should be a graveled ring or berm around the foundation to prevent erosion and to keep the grass and weeds away. The concrete ring wall or slab should be held to close tolerances, and when the tank is completed some record of elevations should be taken at several points around the foundation in order to accurately determine the amount of settlement which may occur.

This may later avoid argument if any shell rings are buckled during or after construction or if a floating roof does not function properly. The foundations of any building that cost $100,000 would receive a lot of consideration. A tank that costs as much and may hold $1,000,000 worth of flammable product should not receive less.

Types Available

Papers presented at the 1952 API Symposium on Evaporation Losses made it clear that the selection of any particular type of tank for a particular service with optimum economy is an individual problem.

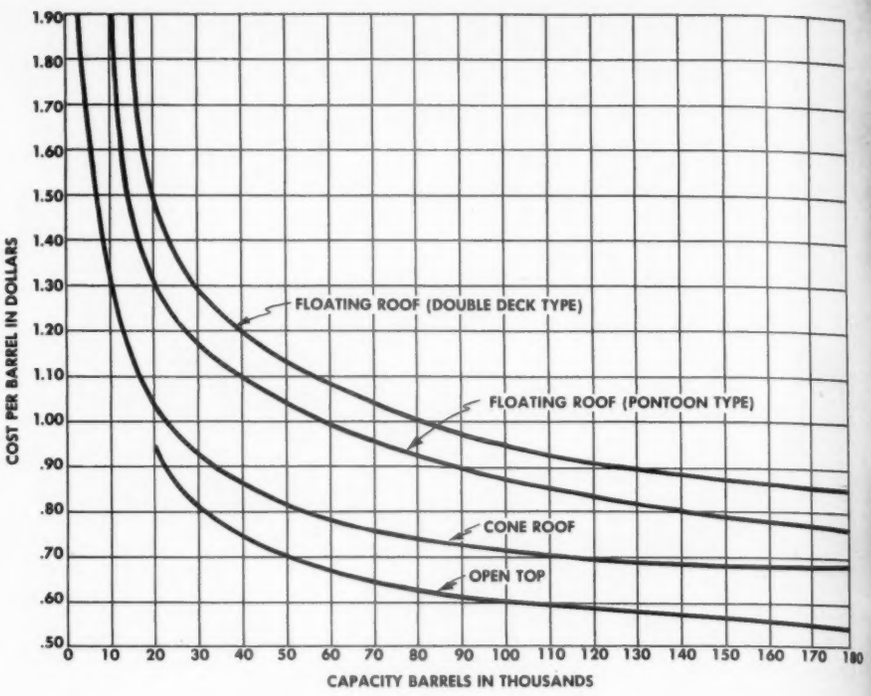


FIG. 1.

Variable vapor space tanks have their advantages and particular fields of application, but our company, with some exceptions, has generally built tanks with cone roofs or the several types of floating roofs for liquid storage. The cone roof tank is familiar to all and needs little discussion except in connection with accessories and costs.

Of the floating roof, there are several types — pan, single-deck pontoon, and the double deck. All of these are basically the same in that they are installed in open-top tanks and float on the oil with some kind of vapor-seal arrangement between the shell and movable roof. They differ somewhat in details and proprietary devices. It is desirable to have a fairly clear understanding of these differences and to be sufficiently specific in inquiries and requests to insure getting what is wanted and to make an intelligent choice of those offered.

The floating roofs that Sinclair usually purchases are either the double-deck or some variety of the single-deck pontoon roof. The company has a few old pan roofs here and there, and while they are cheaper in first cost than other types, it is doubtful that any more will be purchased for general use because of their instability and other disadvantages.

The double-deck roof has a top and bottom deck plate over the entire roof, separated by an air space divided into liquid tight compartments. Its principal advantages are that:

(1) It has considerable strength and structural stability;

(2) fair surface drainage;

(3) the center or low part of the upper deck is practically always above the liquid level of the tank;

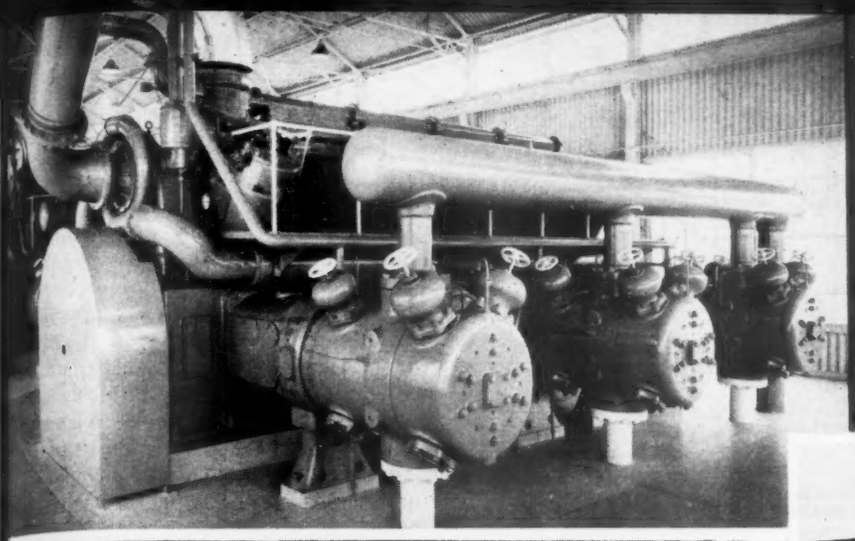
(4) it will support a large weight of snow and ice but has a low storage capacity for rain water;

(5) barring serious accident it is practically unsinkable. It usually costs more than other types, however.

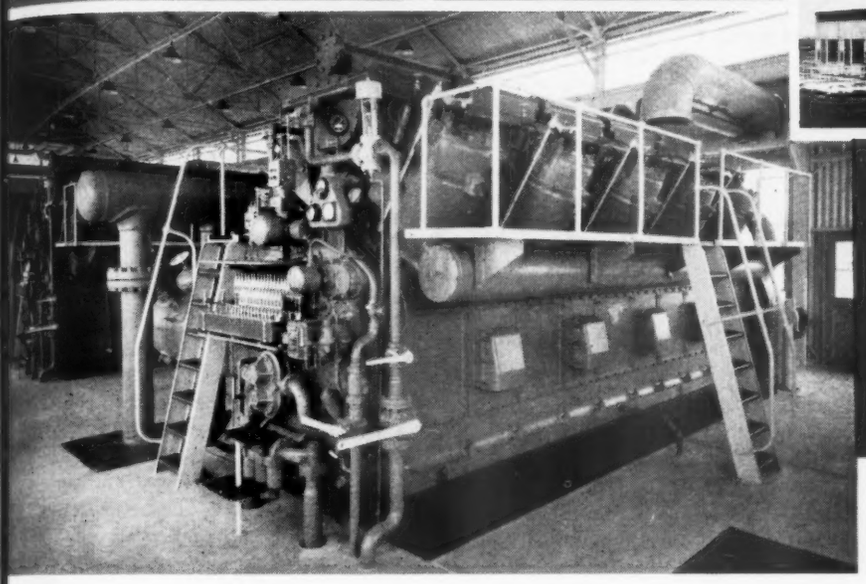
The single-deck pontoon roof has a single-plate deck surrounded by a circular chamber or pontoon divided into compartments. Some have an additional pontoon in the center while another type has a large center weight to provide a better drainage slope, which is otherwise flat and may even be high in the center.

The only advantage of the single-deck roof over the double deck seems to be that it is cheaper in sizes over approximately 10,000 bbl. The roof is flexible and not as strong as a double deck, will not safely carry the same load of snow and ice, and has a large water storage capacity. The deck plate in the center portion is usually flat, and the drainage is very poor. It is difficult to keep this portion painted. Since the center of the deck is below liquid level, under some conditions the tank contents can back up onto the roof unless a hose or pipe drain is used. It does not have the same factors of safety as the double-deck roof.

A sub-type of pontoon roof has a vapor space under a portion of the



These installation photos show the new Cooper-Bessemer GMVA compressors which are identical in both the Keyes, Oklahoma and Springfield, Colorado transmission stations of the Colorado Interstate Gas Company. Below are exterior views of the compact Keyes (left) and Springfield (right) stations.



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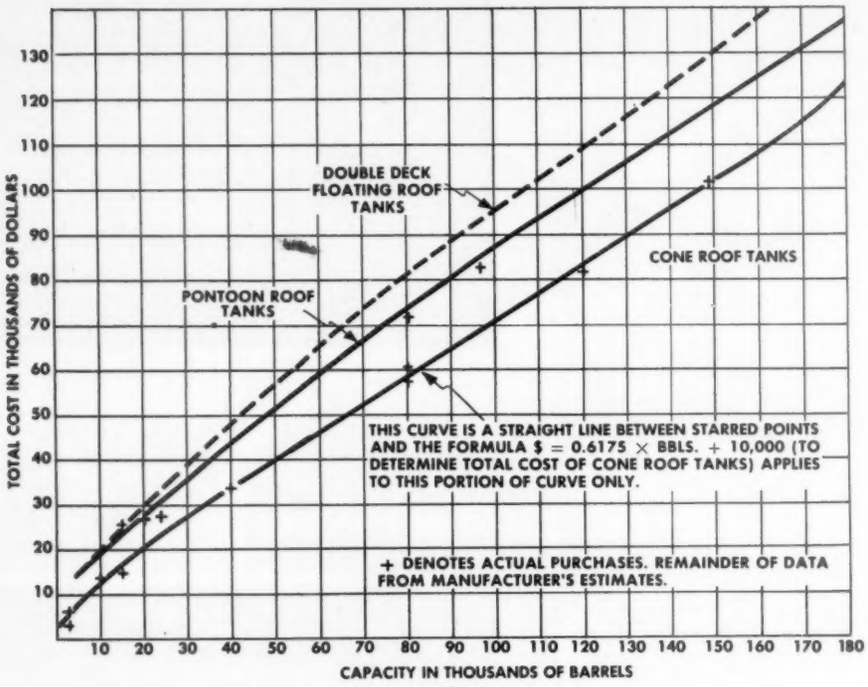
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CAPACITY IN THOUSANDS OF BARRELS
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CONE ROOF TANKS
PONTOON ROOF TANKS
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+ DENOTES ACTUAL PURCHASES. REMAINDER OF DATA FROM MANUFACTURER'S ESTIMATES.

FIG. 2.

single deck. The purpose of this construction is to provide a steeper slope than is otherwise obtainable in the ordinary single-deck roof. It also offers a variable volume space for vapors trapped or generated under the deck. The better drainage slope is somewhat offset by the condition around the center pontoon in roofs of large diameter where water is supposed to flow around the valley to the drain but often does not. The vapor space under this roof is at times a disadvantage, since corrosion of the underside of the deck is more likely to occur here if sour products are stored. The cost of this roof is not much different than other single-deck pontoon roofs.

With regard to vapor loss, no data is available for comparing the double-deck and pontoon roofs, but it seems doubtful that there is any material difference. Under conditions of surface boiling, the single-deck roof has a bubble of vapor that is probably as effective insulation as the air space of the double deck. Therefore, the double-deck roof must pay off in greater safety, less painting, a better maintenance record, and longer service life to justfy its extra cost.

Cost of New Tanks

The cost curves presented here in Fig. 1 and 2 were plotted from data obtained from several sources. They include erection but not foundations, dykes, or piping. Some of the figures were submitted by various manufacturers for estimating purposes while others represent actual bid or purchase prices from 1951 through 1953.

In plotting these curves, it was attempted to give a little more weight to those values representing actual purchases. The curves at best only approximate average conditions and costs of tanks of normal proportions. There are a number of variable factors affecting costs such as geographical location, climatic and field conditions, labor and material costs, the size of job, and the competition. It is believed, however, that they do point to some trends that might govern our selections. It is quite apparent that, if consistent with manufacturing and operating conditions, the largest tanks are the most economical. It is also apparent that the cost per bbl of storage rises sharply below about 40,000 bbls so as to make small tanks uneconomical unless they are limited to small capacity by operating conditions and the amount of product available for storage.

It will be noted that in smaller sizes there is a tendency toward a convergence in the costs of double-deck and single-deck pontoon roofs. This is supported by information from manufacturers that below about 10,000 bbls there is not a great deal of difference.

There also seems to be a slight tendency toward convergence in costs of the pontoon and the cone roofs in larger sizes. In some cases, it may be found that a pontoon roof costs little or no more than a cone roof. If we take into consideration the venting equipment and other cone roof appurtenances and the fact that the under side with all of its framing is particularly vulnerable to corrosion, the advantage of the floating roof is more apparent.

Fig. 3 is a graph showing weights of various types and sizes and the cost in dollars per ton of cone roof tanks. These weights were taken from manufacturers published data for tanks having average diameter-height ratios.

Other Factors of Selection

There are no standards for tank sizes either from manufacturers or the API. Manufacturers will construct any diameter or height that the customer wants. There are, however, some fac-

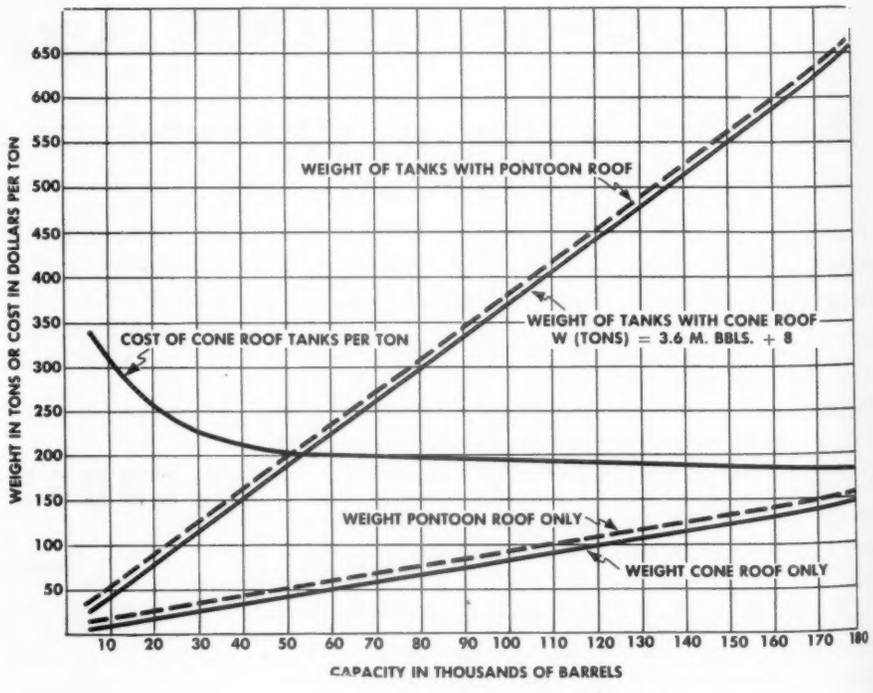
WEIGHT IN TONS OR COST IN DOLLARS PER TON
CAPACITY IN THOUSANDS OF BARRELS
WEIGHT OF TANKS WITH PONTOON ROOF
WEIGHT OF TANKS WITH CONE ROOF
W (TONS) = 3.6 M. BBLS. + 8
COST OF CONE ROOF TANKS PER TON
WEIGHT PONTOON ROOF ONLY
WEIGHT CONE ROOF ONLY

FIG. 3.

tors of size that affect price to a minor extent and should be considered when ordering. The selection of diameter is limited only by capacity desired and ground space. The choice of tank height is generally limited by available pumping head, the supporting capacity of the soil, and the economic selection of plate widths.

In the latter case, plates ¼ in. and thicker are readily available in 8 ft widths and 3/16 in. plates in 6 ft. widths. Wider plates can be obtained, but the size extras may make them uneconomical. Manufacturers say that the most economical tank height is usually one using multiples of these stock widths and that for small tanks the height and diameter should be about the same if consistent with this selection of plate width and other factors.

The supporting value of the tank grade, of course, is a variable but for foundations without piling 3000 lb per sq ft seem to be a conservative value. Since this is the weight of 48 ft of water, it limits tank heights unless the ground is unusually good or unless piling or some other type of deep foundation is used. There are locations where 48 ft would be excessive, particularly where a large diameter tank is to be constructed or a number of closely spaced smaller ones. Some caution should, therefore, be observed in choosing tank height.

In purchasing a floating roof tank, it should be remembered that, due to roof displacement, the full capacity of a cone roof tank of equivalent dimensions is not obtained. If this full capacity is important, it should be clearly specified in the inquiry and order and the proposed design examined for this feature. The manufacturer can adjust the height and diameter to compensate for the displacement of the roof and give full capacity.

If tanks with floating roofs are to be frequently operated at full capacity, it may be desirable to provide a skirt plate or extension all around and above the normal shell rim in order to contain the seal shoe and provide a better seal against evaporation due to windage when the tank is full. Without such a device the seal shoes are projecting above the tank and the area in contact with the shell below the liquid level is much reduced. If the roof has a secondary seal, it is also inoperative and in some cases may be damaged when the roof descends.

This skirt plate or shell extension must have slotted holes or openings of some sort all around at the design height of shell. Otherwise, if the liquid level rises above this point, the lower shell rings will be over stressed. There is some objection to the use of this skirt plate with slotted holes or openings on the basis that the tank is more likely to be overrun since the seals are below the top and invisible. The validity of the objection depends upon the methods of operation.

Fittings and Appurtenances

When purchasing any type of tank, be specific as to type of fittings and attachments desired. These have considerable to do with the successful operation of the tank, and lack of specification may lead to later charges for extras or dissatisfaction in operation.

A few dollars saved in initial cost by eliminating needed fittings or using inferior equipment is usually poor economy. When a tank once goes into service it may be several years before the desired appurtenances can be installed and even then the down time and extra cost of making the tank safe for welding may preclude installations.

Drainage Devices

For floating roof tanks there are several choices of drainage devices. The internal jointed pipe drain and the hose drain conduct rain water to the outside of the tank and require a special shell connection in addition to the conventional water sump and draw-off pipe connection. The jointed pipe drain usually requires a large oval manway in the shell for its installation and removal.

If the joints leak, the product leaks out the open valve, and if the valve is closed the pipe fills with oil or water, which may freeze. The hose drain has been improved in recent years by using synthetic rubber, non-kinking devices, and provisions for removal and replacement without complete emptying and purging of the tank. All things considered, it seems to be preferable if internal drainage into the product is objectionable.

Syphon or straight-through drains may be used where the rain water draining down through the tank contents is not objectionable. In the double-deck roof, this is a simple drain with a seal to trap vapors and prevent evaporation. The product cannot back up onto the roof since the roof deck is above the liquid level.

In the single-deck roof, a syphon drain is used for the same purpose. It usually has a suspended container filled with water, and the difference in gravity between the water and oil prevents the product's backing up onto the roof, which at this point is lower than the oil level.

If the water in the syphon drain evaporates or is displaced, the product may back up onto the low part of the roof. These drains may freeze in winter and require salt or steam to keep them operative, which is another argument for the hose drain. We believe that, in addition, all floating roofs should have vapor-sealed overflow emergency drains.

Gaging Equipment

In gaging devices there is a wide choice ranging from the simple float and gage board type costing less than $200 to the electric remote reading kind which costs $1000 or more, depending upon how many tanks are connected and their distances from the indicating board mounted instrument. It appears that less dependence is placed on the old gage board type than formerly and that a better and more accurate and dependable gage is desirable.

The pipe line companies have found the remote reading gages advantageous. Gage floats in floating roofs usually have float wells furnished and installed by the manufacturer. These permit gaging down below the floating point of the roof and are superior to attaching the gage cable to the roof structure. Floats in cone roof tanks will have three guide wires, and when there are tank mixers or other violent agitation, a 12-in. perforated stilling well or pipe should be used to contain the float.

Regardless of what types of gaging devices are installed, there is still a need for the conventional hatch for making hand tape gages. Some use a gage well pipe on floating roof tanks in order that these gages can be taken from the top platform without going down onto the roof deck. This is a time saver, and contributes to safety at a nominal cost. Most manufacturers can furnish standard details of this device.

Venting Equipment

With respect to cone roof tank fittings, it is probable that in some cases venting equipment is undersized for best operation and safety. Some of this equipment was installed when it was the practice to use reciprocating pumps. Since then more modern equipment has been installed and rates of filling and emptying have been increased. It is wise to check these older installations for size and replace or supplement them with additional vents if found deficient.

When new equipment is purchased, the necessary sizes are computed by the rules of the API Venting Code, with consideration being given to possible changes in service rather than picking some nominal size which may have been used on a previous installation. It is cheap insurance against roof collapse or evaporation losses due to leaving roof hatches open.

5" x 8" Card

Blank Refinery — Tank Painting Record — Tank No. _____

Location _____ Service _____
Diameter _____ Height _____ Capacity _____
Type of Tank — Cone Roof _____ Floating Roof _____ Open Top _____
(Check One) Horizontal _____ Pressure _____ Other _____
Square Feet of Surface _____ Date Last Painted _____

Procedure:
Surface Preparation _____
_____ Manhours _____
Prime Coats _____
_____ Gallons of _____ Manhours _____
Finish Coats _____
_____ Gallons of _____ Manhours _____

Date of Completion _____ Total Manhours _____
Remarks _____
_____ Foreman _____

Reverse Side

Paint Inspection Record — Tank No. _____

1. Date _____ By _____ Condition _____
Recommendations _____

2. Date _____ By _____ Condition _____
Recommendations _____

3. Date _____ By _____ Condition _____
Recommendations _____

FIG. 4.

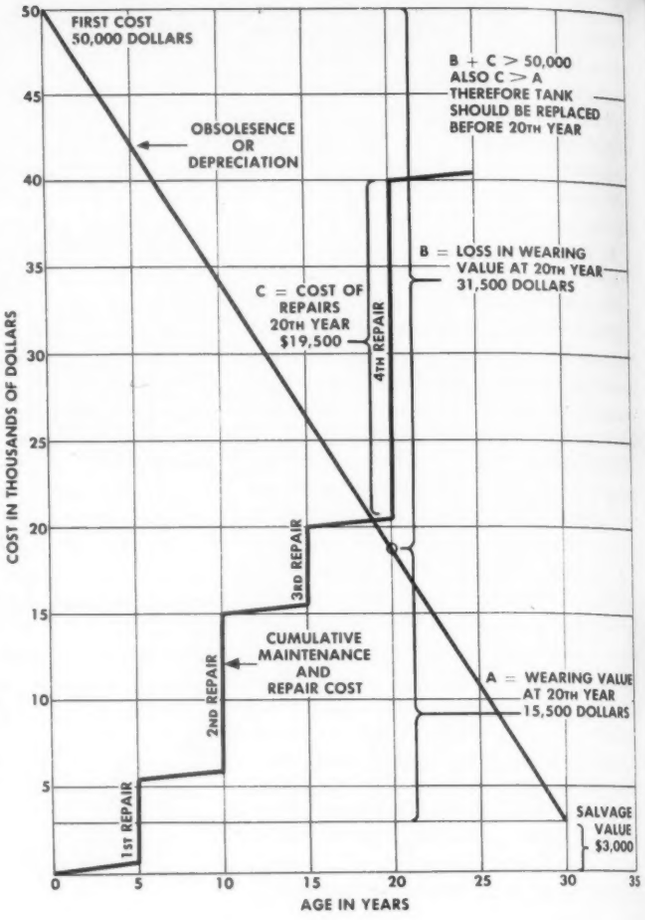

FIG. 5.

In northern areas, there is the possibility of the valves in conservation vents freezing shut from condensate in the product or from blowing rain or snow. In future installations of such equipment in norther areas, an attempt should be made to select types which are least susceptible to this difficulty.

Flame Arrestors

The value of flame arrestors has recently been subject to some reappraisal. Some oil companies take them out in winter and others do not use them at all. The National Fire Association and the National Bureau of Fire Underwriters have recognized the problem, and the latter in its pamphlet No. 30 issued in 1953 reflects this in the implication that it is not necessary to use flame arrestors if conservation vents are used. It also states that condensation and crystallization of certain products and freezing in winter may make either of these devices impractical in very cold weather.

Since a flame arrestor element reduces the capacity of a conservation vent valve by as much as 20 per cent, its removal may greatly improve some present cases of inadequate venting and make additional vents unnecessary. These flame arrestors are both cumbersome and expensive. In the future, it is Sinclair's intention to use them only under special conditions where hazards are extraordinary, in services where they are not likely to become fouled with waxy or sticky deposits, and where they can and will be frequently inspected.

Flush-Type Cleanout

A shell fiitting which has only recently been included in the API Standards is the flush-type cleanout. While this device is rather expensive, particularly in larger sizes since it must be stress relieved with the shell plate in which it is installed, it offers some new possibilities for tank cleaning.

If about four of these fittings in the smaller sizes are spaced around the tank, it is possible to remove a considerable amount of sludge through them by directing hose streams through the shell manways before any men enter the tank. The clean-out cover may be equipped with a pipe connection for pumping or open sluices may take the sludge directly to pits in the dyked area.

One company using these fittings places a radial diverter plate in each opening to divert the swirling sludge. Another company has had some success in using a truck-type hoist bin lowered into a concrete-lined pit adjacent to a large flush opening. The sludge is scraped into the bin, which is lifted out of the pit and hauled away.

This fitting is made in sizes from 8 to 16 in. to 4 by 4 ft maximum. In addition to requiring stress relief, there are several critical design features. It also requires provision in the concrete foundation for the extra thickness of bottom reinforcing plate and for removal of the flange bolts. It is urged that no home-made clean-outs of this sort be installed unless the specifications are followed.

Water Draw-Off Connection

One detail of tank equipment that needs improvement is the water draw-off connection. This gate valve connection is frequently used as a pumpout connection when cleaning the tank and has customarily been packed in winter to prevent freezing. Many have eliminated this nuisance by installing an oil connection ahead of the draw-off valve to displace the water in the pipe when the valve is closed. Sinclair intends to make this a standard detail for all cold weather locations using heavy seamless pipe and steel fitttings and keeping the oil connection to the tank low enough to be effective when the contents are drawn down.

Sinclair's standards for tank fittings specify a minimum of two shell manways, with four on larger tanks, and

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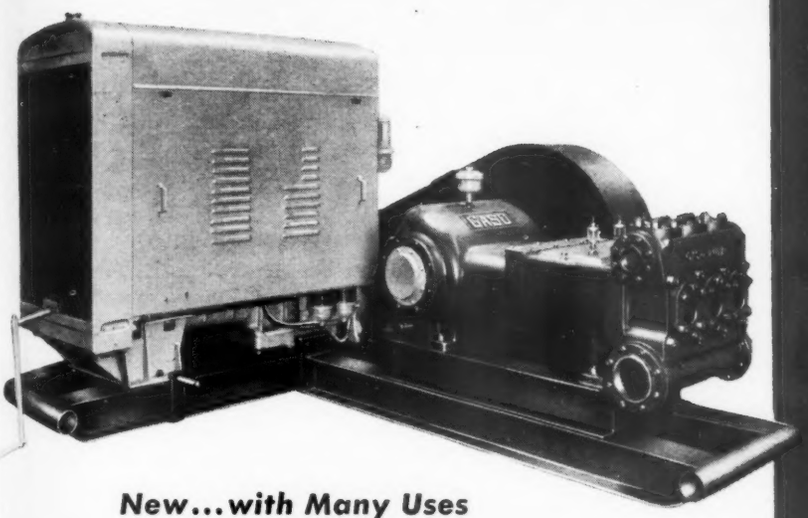

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Type

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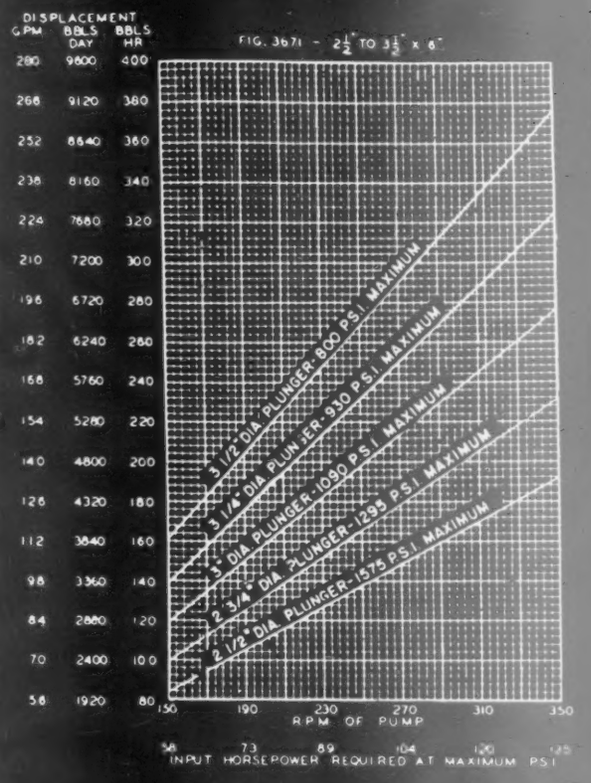

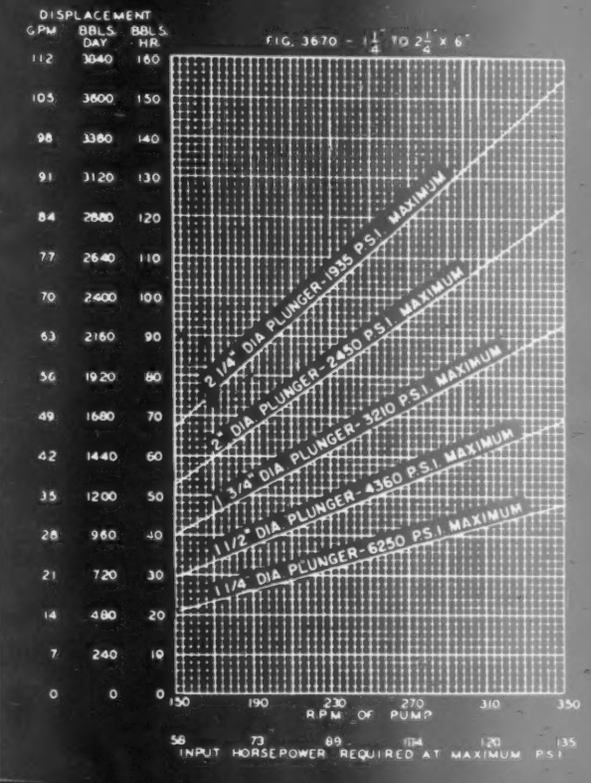

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XUM

also an equal number of roof manways, usually equipped with aluminum-hinged covers. On large tanks two internal sumps and water draw-off connections on opposite sides are specified.

It is felt that all of these are a great convenience in cleaning and that their additional cost is quickly repaid by reduced labor and down-time and greater safety. It takes very few trips up a tank stairs with tools to unbolt flanged manways to pay for quick opening covers.

Maintenance

All of these devices, as well as the tank, require a certain amount of inspection and maintenance to preserve the investment and to prevent unnecessary losses of product and expensive repairs. Broken sample bottles, scrap iron, and other litter on tank roofs shorten paint life and introduce hazards to personnel. Water seals, conservation vents, flame arrestors, gage hatches, floating roof seals, and drains all require some attention to keep them operative and to prevent loss of product.

Many older cone roof tanks have settled, causing the roof to sag slightly and form pockets of plate buckles around the outer edge. These hold water and corrode badly. When the tank is empty for cleaning or repairs, the condition can be corrected by jacking up and shimming the columns. In many old installations, better drainage of the area immediately around the tank and removal of accumulated silt will pay off in longer paint life and less corrosion of the bottom ring and tank bottom plates.

Tank Painting

Since tank painting is a constant source of maintenance expense, Sinclair is giving it some study in an attempt to reduce it. We find that it is costing from approximately $1.00 to $2.53 per square (100 sq ft of tank surface) per year to paint a new tank and to keep it painted over a reasonable life span. The variation in costs is due to the differerent exposure conditions at the various plants and the kind of job that they are doing. The general average is $1.51 per square or about 1½ cents per square foot per year for all the painted tank surface. A simple formula for determining annual unit cost and evaluating procedures is shown in Fig. 6.

As might be expected, the labor cost is the principal element of expense, and material cost is secondary. We are, therefore, trying to reduce the labor cost and increase the durability of each paint job. We are experimenting with different methods of surface perparation such as pickling and the use of

COMPUTATION OF ANNUAL, UNIT TANK PAINTING COSTS
(Direct Annual Basis)

Assume that a tank is painted when new at an intial cost (of surface preparation, etc), which may be higher than a repaint job. What is the annual cost of painting the tank and keeping it painted over a definite period of N years?

C_a = Average annual direct unit cost (per 100 sq ft)
C_n = Unit cost of initial painting (when new) (per 100 sq ft)
C_r = Unit cost of repainting at definite periods (per 100 sq ft)
L_n = Life in years of the initial paint job
L_r = Life in years of a repaint job
N = Life expectancy of the tank

Then

$$C_a = \frac{C_n + C_r\left[\frac{N - L_n}{L_r}\right]}{N}$$

Example

N = Assumed 25 years
C_n = $11.86
C_r = $6.88
L_n = 5.93 years
L_r = 5.71 years

$$C_a = \frac{11.86 + 6.88\left[\frac{25 - 5.93}{5.71}\right]}{25} = \$1.39 \text{ per 100 sq ft per year.}$$

EFFECT OF INCREASED LIFE WITH INCIDENTAL INCREASED PAINTING COST

For simplicity assume the life expectancies of the initial paint job and a repaint job to be the same:

$L_n = L_r = L$ and $N = 25$ years
Let x = An increment of added life in years
and y = An increment of added cost in dollars to both a new and subsequent repaint jobs to attain this increased life.

To effect any saving:

$$\frac{(C_n + y) + (C_r + y)\left[\frac{25 - (L + x)}{(L + x)}\right]}{25} < \frac{C_n + C_r\left[\frac{25 - L}{L}\right]}{25}$$

After reduction this inequality becomes:
$L_y < C_r x$

Example:

Assume $L = 5$ ye ars and $C_r = 3.65$

If we add an extra coat of paint or some procedure to each paint job that increases L by 3 years, then the most we can pay for such additional treatment to break even is:

$$y = \frac{3.65 \times 3}{5} = \$2.19 \text{ per square for each paint job.}$$

Or suppose that we add some procedure such as an extra prime coat and more expensive finish coat material which costs $4.00 extra per square for each painting of the tank. In order to save any money we must get an increased increment of life "x" to compensate for the increased increment of cost "y" = $4.00.

$$\therefore x > \frac{5 \times 4}{3.65} \text{ or } 5\tfrac{1}{2} \text{ years, and } L + x \text{ must be } > 10\tfrac{1}{2} \text{ years.}$$

certain products which are claimed to eliminate the need for complete sandblasting, which cost from $6 to $8 per square.

This is a big factor in both painting cost and durability. We are trying different methods of application, such as roller coating, to reduce labor costs. We are working closely with our paint department, which makes all of the paint we use, in trial applications of various paints to improve durability and perhaps to reduce product evaporation at the same time.

Some tentative conclusions, while not startling, are still significant. It is believed that, assuming equal materials and exposure conditions, better durability will be obtained from adequate surface preparation. To date we have found nothing better than complete sandblasting and immediate painting.

Paint film thickness is also a factor, and assuming adequate preparation and drying time between coats, thicker films last longer than thin ones. We are, therefore, specifying a minimum of 4 mils (.004 inches) dry film thickness. It is felt that roller coating should be used more in preference to brushing as a means of cost reduction. Finally, we believe that some saving can be obtained by repainting before the prime coats have been seriously damaged by weathering.

Much exterior painting is done for appearance, and the major corrosion problem is inside the tank. An attempt is being made to find some solution that is cheaper than extra metal, but thus far, the cost of internal surface preparation, toxicity of various products, and other difficulties of application have been deterrents.

Progress in this direction has necessarily been slow, but it is felt that some is being made even though many of the things learned may have only negative value. In order to know whether any progress is being made, it is necessary to have some records of what has been done. Most of our refineries stencil the tanks with dates of painting and keep some sort of tank painting record. A good form for that purpose arranged for typing on 5 by 8-in. file cards is shown in Fig. 4.

Inspection

The useful life and serviceability of a tank being contingent upon the condition of its parts, periodic inspections are necessary to determine its condition and to anticipate repairs, which on occasion may be extensive enough to dictate replacement. A guide for such inspections is Part IV of the API Recommended Practices for Refinery Inspections, published in 1951 by the API Division of Refining. The inspection and data forms given there are especially useful.

In this manual under Section 4, Determination of Limits, are rules for determining the minimum allowable corroded shell plate thickness. The rules state that isolated corrosion pits may be ignored provided they are not deeper than one half the allowable design thickness and provided that the average metal thickness, along any line through the pits or corroded area and normal to the direction of maximum stress for a length of 16 times the design plate thickness, shall not be less than 85 per cent of the allowable or original design thickness.

In effect, this permits a 15 per cent reduction of design thickness for corrosion, which in turn raises the basic plate stress from 21,000 psi to approximately 25,000 psi. In view of current uncertainty concerning brittle fracture in carbon steel tank plates and the fact that more corrosion is apt to occur adjacent to the welded seams, especially in older tanks, it is felt that this value should be used as a basis for recommending replacement of shell plates.

In addition to this provision of the inspection manual, it is proposed that when any plate or member is corroded down to an average thickness of two-thirds of the design thickness (or nominal thickness in the case of members such as the roof, bottom, upper top ring, etc., which are not subject to primary stress from hydrostatic loading), the tank or parts involved should be taken out of service as being unsafe. The top rings and roofs of large tanks are rather flexible when badly corroded, and it is possible for a high wind to cause collapse and possibly a progressive tearing failure.

Tank Retirement

Internal corrosion is a major cause of tank obsolescence, and its rate is difficult to predict. Changing requirements, improved equipment, and the need to utilize ground space effectively are perhaps just as important factors in obsolescence and more difficult to predict.

Tanks might be kept serviceable indefinitely by constantly renewing parts as they wear out, but such a procedure would be uneconomical. Eventually it would result in a serviceable old tank, outmoded in type, inefficient to operate, deficient in capacity or even too large, and perhaps occupying space needed for other purposes.

There will also come a time when the cost of repairs to make it serviceable plus the reduction of wearing value will equal the cost of a new tank. Certainly this is the time to replace it. If it is assumed that a 30-year period represents about the average life of a tank before it becomes obsolete because of type, size, or location, the time for retirement may be shown graphically as in Fig. 5.

Here it is assumed that a new tank with appurtenances costs $50,000 and that it will be obsolete in 30 years and sold for scrap at say $3,000. The diagonal line is the obsolescence or depreciation curve, and ordinates to it, less salvage value, represent its wearing value or its value as a utility at any time.

The curve might be steeper due to rapidly changing requirements, but a 30-year slope to scrap value seems a reasonable average and consistent with tank history. The stepped curve represents an assumed cumulative maintenance and repair cost.

Where the curves cross is not significant since we are not concerned with money that has been spent but only with what we shall have to spend and the value we will get for it. At some time it is likely that unusual repair expense can be foreseen such as shell ring replacements and perhaps a new bottom or roof. The cost of these repairs plus the reduction in wearing value up to this time may equal or exceed the cost of a new tank and it probably is more economical to replace it.

This point is subject to some control by staggering or bunching the repairs and deferring some for a year or two. It is also contingent upon the service conditions, severity of corrosion, and extent of repairs necessary. But if for any definite short future period the anticipated aggregate maintenance and repair expenses will exceed the average wearing value for the same period, it is probably desirable to retire the tank and to spend the money on a new one.

In many instances, floating roofs have been installed in old riveted shells where perhaps a more rigorous analysis would indicate that complete replacement was desirable. The old riveted shell is difficult to keep tight and painted. The rivets hinder the operation to some extent, causing more maintenance on the roof seals and more evaporation loss than a smooth shell. Frequently, the old tank has only an earth grade and some settlement may have occurred making straightening and plumbing necessary. A wind girder must be added and sometimes shell fiittings.

Many tanks of this age have a large diameter to height ratio, and cost of the new roof, being a function of diameter rather than capacity, may be excessive. All considerations, plus the fact that the tank is probably not the most desirable size for the new service, will often make a complete replacement the more attractive investment.

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Baseband Utilization

. . . in frequency division microwave systems

Harold R. Reiss

AN OVERWHELMING PROPORTION OF the extensive microwave radio communication facilities in use today utilizes a baseband extending from near zero frequency upward to hundreds of thousands of kilocycles. This baseband is the total intelligence-bearing composite signal that modulates the radio frequency carrier of approximately 1000 megacycles or above. Individual circuits, which can be used for telephone, supervisory control, and numerous other communications functions, are derived by means of either time division or frequency division techniques.

The widest basebands, extending up to 20 mc, are used by the transcontinental common-carrier telephone microwave systems operating in the 3700-4200 mc band. These systems, which span the continent, are the "heavy carriers" in system-loading capabilities and circuit miles in use categories. These systems use heterodyne repeaters, which do not require demodulation and remodulation of the baseband at repeater points, and thus make possible better quality long-haul circuits. Single sideband frequency division-type voice multiplex equipment is used because of maximum conservation of baseband and RF spectrum space for a given amount of transmitted intelligence.

Typical baseband characteristics of a single sideband frequency division system are as follows:

Frequency range	300 cycles-160 Kilocycles
Amplitude variation	Not to exceed ±1.5 db over frequency range (reference to 10 kc).
Level variation	±1 db
Maximum input level (per channel)	—26 db
Maximum output level (per channel)	—10 db
Signal-to-noise + crosstalk in any 3 kc derived channel	at least 45 db (not including 300-3000 cycle range)

The above characteristics show a rather wide-band private communication channel that is capable of being subdivided into telephone, teletypewriter, telemetering, facsimile, and supervision control circuits. By utilizing established communication techniques, 30 or more telephone-type circuits plus a maintenance-order circuit may be provided. In frequency-division multiplex systems, telegraphic-type circuits such as teletypewriter and telemeter-control may be added directly to the baseband, either in lieu of one or more voice channels or by superimposing them on voice channels as required. It is generally preferable to operate telegraphic-tone channels directly on the baseband due to simpler equipment arrangements and greater economy.

Time division multiplexing may be used to adavantage where a large number of point "A" to point "B" circuits are required with no intermediate drops. The complexity increases, when intermediate synchronization points are added to such a system. Maintenance problems likewise become difficult.

Double sideband-transmitted, carrier-type, frequency-division multiplexing equipment may be used with a reduced number of circuits. This is due to the wider spectrum covered by the double sideband signal and the system-loading effects created by the transmitted carrier and second sideband. Circuit layouts are very flexible, but double sideband circuits are not generally used, however, because difficulity is encountered in "party line" or bridged circuits.

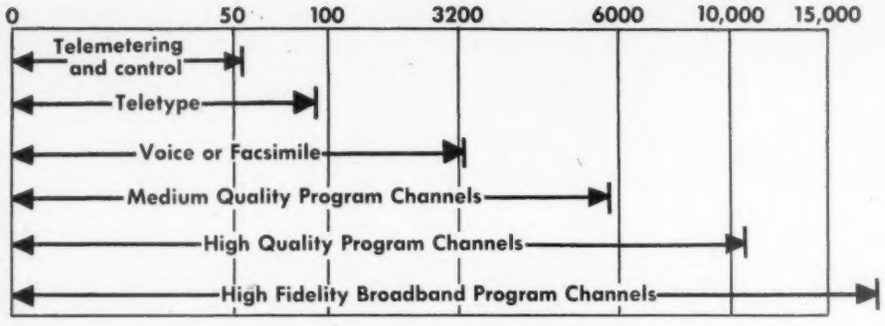
Single sideband suppressed-carrier voice multiplexing is the type generally used in communication systems. Because each channel operates independently, outages due to failure of common equipment are reduced. Spectrum occupancy and system loading are also at a minimum because only those signal components necessary to the re-creation of the original signal are transmitted. Minimum baseband loading assures a maximum number of circuits, with better noise, crosstalk and distortion values.

Voice channels in a single sideband systems are normally spaced every 4 or 5 kc throughout the baseband. Sufficient guard bands between channels are provided for high-quality voice channel widths of approximately 4 kc (from 200 to 3200 cycles) plus signaling. This is possible without the use of critical bandpass or band separation filters. Mechanical filters will probably further improve and simplify single sideband multiplex systems.

The baseband of a microwave system is practically impervious to weather. Ice, rain, and snow cannot collect on a microwave beam, and neither add attenuation nor break it.

Utilization

The baseband utilization aspect of this broad two-way communication channel is very straightforward. It is



Average bandwidth requirements of various type channels (with guard bands).

customary to use the frequencies up to 3 kc for the service-maintenance channel. This channel provides a signaling-talking circuit on a party line basis between all stations for line-up and maintenance purposes. In addition, fault indication equipment operated by a tone, or tones, which is usually installed to operate on this channel, automatically indicates whenever several selected maintenance conditions exist.

Typical conditions may include indications of reduced transmitter output, standby equipment cut in, tower light outage, power failure, operation of emergency engine-driven generator, an illegal entry, and a host of other conditions.

The frequencies immediately above the service channel should be considerered in relation to the ultimate requirements for telegraphic-type tone circuits. Such circuits occupy a spectrum space of from 100 cycles up to 1 kc or more, depending on the specific tone equipment used and required speed of signaling.

Relatively slow speed supervisory control and telemetering channels, may use a bandwidth up to 100 cycles. Sixty-speed teletypewriter circuits occupy 100 to 150 cycles. One hundred word per minute-speed teletypewriter circuits use somewhat increased bandwidth. Amplitude-modulated type tone channels are generally preferred because of lower cost and narrower channel requirements. Frequency-modulated type tone equipment, which has been used very successfully, occupies a little more spectrum space with improved performance during infrequent marginal operation due to abnormal propagation conditions.

Very high speed-tone equipment used for power relay protection applications occupies a bandwidth of 1 kc or more. High speed is a necessary requirement in order to provide immediate operation of circuit breakers to isolate a fault in a power transmission system. The practice of obtaining greater operating efficiency by heavier power-line loading is increasing and placing a more stringent requirement on protective equipment.

Separation

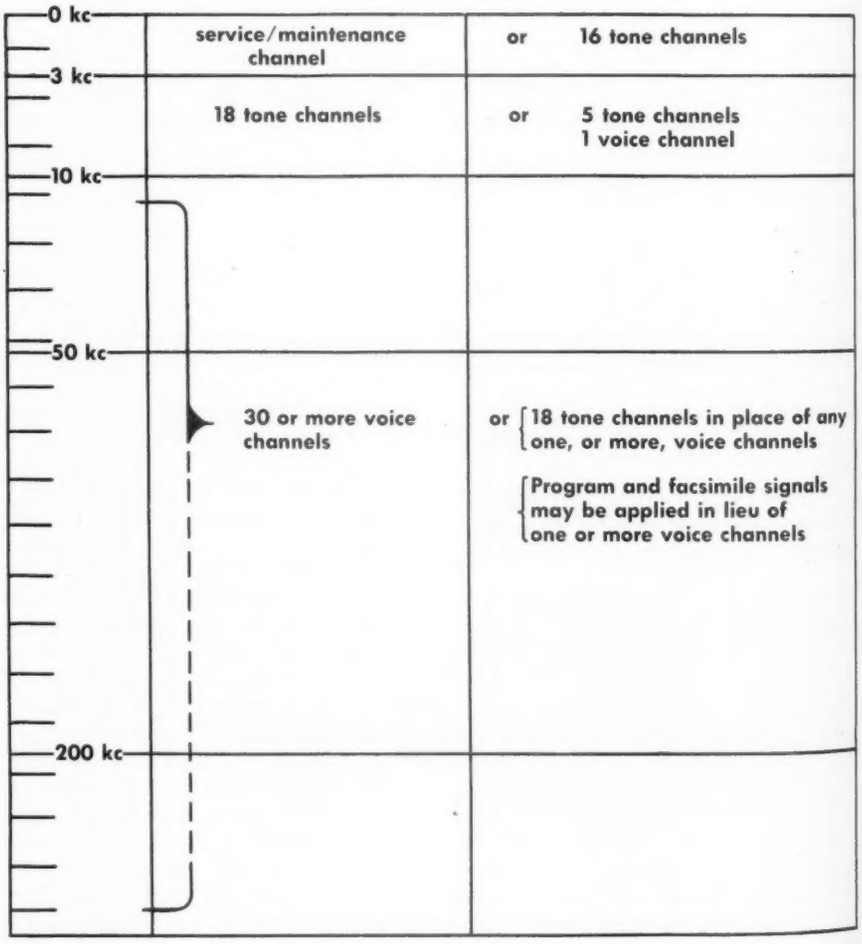
Due to the percentage bandwidth cutoff characteristics of filters, tone-channel frequency assignments are separated 100 to 200 cycles up to the 4000 cycle range. The separation then increases to 400 to 500 cycles in the 10 kc range. In general, as the frequency assignment is increased, the separation must be increased accordingly.

Where the number of telegraph-tone circuits is in excess of 20, the usual practice is to superimpose voice-frequency tone telegraph circuits on derived multiplex voice channels. This allows up to 18 telegraph circuits to be superimposed on each voice channel so equipped.

This, if up to 20 teletype circuits were to be considered for connection directly to the baseband, frequencies up to approximately 16 kc in the service-plus-tone channel range would be used for this purpose.

Voice frequency, program, or wider band circuits are "stacked" above the tone channels as circuit layout arrangements require. As mentioned previously, a single side band, suppressed-carrier voice telephone circuit requires a spectrum space of 4 or 5 kc. Thus, spectrum space remains for an additional thirty or more such circuits on the baseband. The discreet number is interrelated with noise/crosstalk, bandwidth, usage factor, and circuit length considerations. Idle or partially idle circuit conditions must be considered in those instances where tone-off sig-

Typical channel assignments



naling is used for constant supervision in trunking applications. With tone-on type signaling, used in ringdown applications, signal loading is minor. In some installations, program circuits of 5 kc bandwidth have been supplied with a corresponding reduction in the number of narrower band voice channels.

Conditions are sometimes encountered where a very wide band, high-fidelity program circuit of 15 kc is required. In this application, vestigial-sideband type circuits are utilized which provide excellent response for such purposes. This type of channel occupies the space normally required for approximately six voice channels.

Facsimile signals may be transmitted over any derived multiplex channel of sufficient bandwidth. The 3000-cycle voice channels are satisfactory for the slower speed facsimile service most commonly used. As the speed and definition requirements are increased, proportionately wider band channels are required.

Transmission of signals for the interconnection of business machines is very readily accomplished. The type of interconnection usually falls into one of two categories. The first, a card to tape—tape to card system, is readily handled over one or more regular teletypewriter channels. The second, a recent development, may be superimposed on a single voice channel for interconnection of up to four direct card-to-card machines. Full speed operation is attained in conjunction with automatic verification and check-back, thus retaining all the desirable features of this system. * * *

The Author

Harold R. Reiss, a native of Cairo, Illinois, attended Lawrence College and the University of Wisconsin Extension Division. He was employed by the Bell System in Wisconsin from 1927 to 1941. Later, he became vice president and research director of electronics for Sindlinger and Company, Inc., in Ridley Park, Pennsylvania, until joining RCA in 1953 in the microwave product planning department.

Starting early with his lifelong interest in rapid communications, Reiss obtained his first radio license at the age of eleven. He is a member of the IRE (Communications, Microwave Theory, and Medical Electronics Professional Groups).

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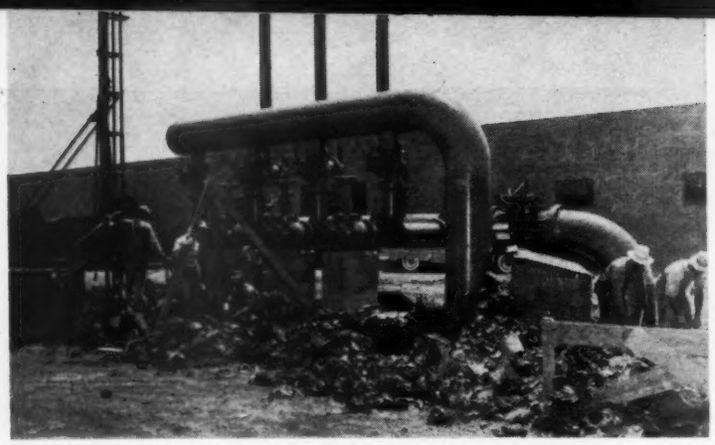
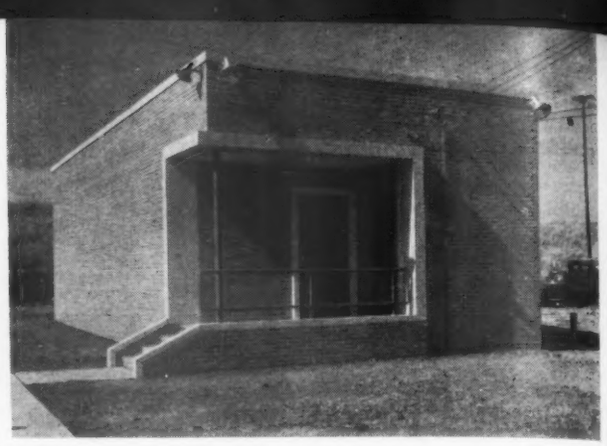
Another typical Emsco microwave installation on Texas Eastern's natural gas pipeline system.





Left—Completed regulator station before building was erected. Right—Building's facade conforms with neighboring architecture.

P 620.

Muffler, Acoustic Materials Aid Pressure Station Noise Abatement

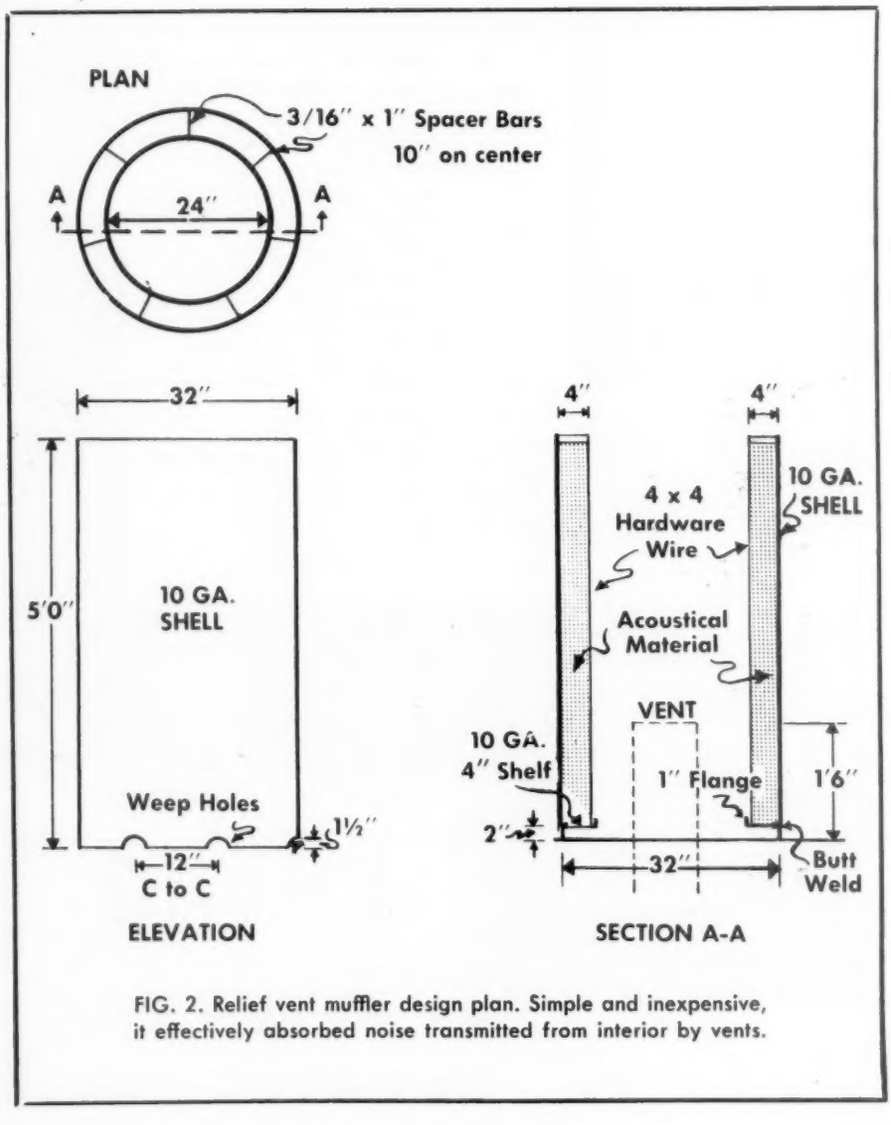


FIG. 2. Relief vent muffler design plan. Simple and inexpensive, it effectively absorbed noise transmitted from interior by vents.

Carol Neaves

Division Engineer,
Dallas Division of Distribution,
Lone Star Gas Company, Dallas, Texas

NOISE as an operating problem is receiving considerably more attention today than in the past, especially by gas pipe line companies whose operations often take them closer to populated areas than do crude and products pipe lines.

The terms "acoustics," "sound control," and "noise abatement" have become increasingly more important in the planning vocabulary of company engineers. They must be prepared to control noises originating and emitting from various types of equipment so that it is not objectionable to neighbors.

A problem involving noise abatement in regulating equipment was recently encountered by Lone Star Gas Company. A pressure regulating station was planned for construction in an area that was rapidly becoming an industrial district. All of the buildings in the area were new, of modern architecture. Lone Star engineers had determined what would be needed in the proposed pressure reducing installation, and designed the building to conform with surrounding achitecture.

They had doubts, however, about the noise problem. The deed to the property purchased contained a restricting clause covering objectionable noises. The company planned to use three 10-in. regulators to reduce pressure from

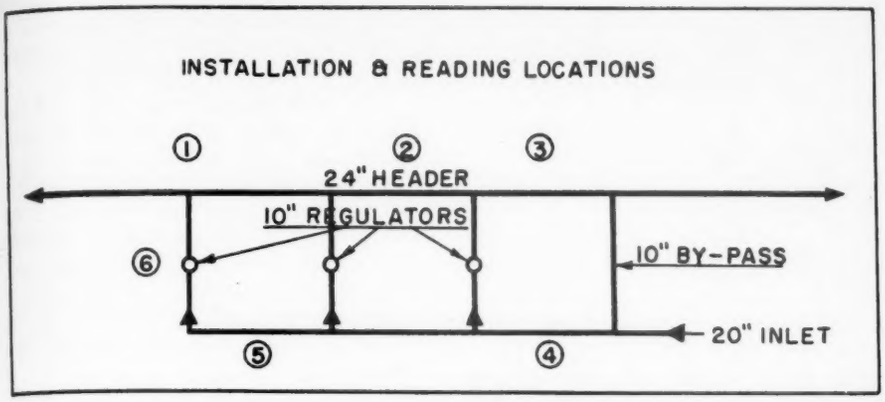
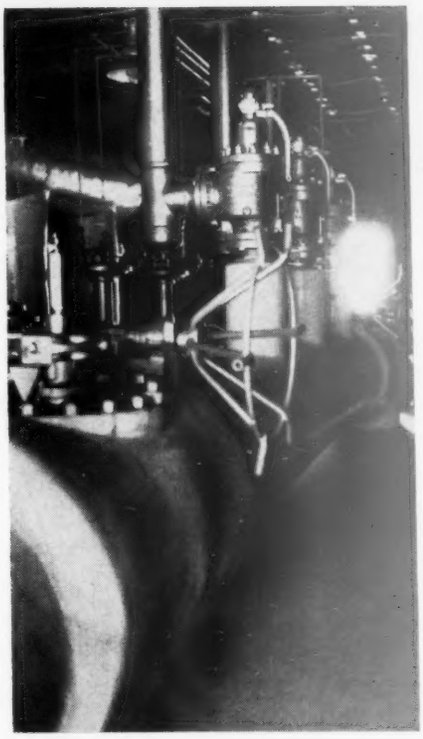


FIG. 1. Schematic drawing of station shows six microphone positions at which effectiveness of soundproofing job was measured.



Successive layers of hair and asbestos felt with asbestos cement and canvas finish-coat were applied to all piping and control surfaces.

175 psi to 25 psi. This equipment, they knew, would create a large amount of noise during certain load conditions.

The building to house the pressure reducing installation and the remote recording and control equipment was designed by an outside architect. For noise reduction, blankets of 2-in. thick banacoustic were to be used on the interior walls and ceilings, covered by a metal lath to prevent damage to the blankets.

No windows were used in the building and ventilators were provided with 1-in. thick air acoustic, 6-in. on center to baffle out the sound.

After the building was completed and gas turned into the installation, the wall insulation appeared to be effective in reducing the noise, as far as the neighborhood was concerned.

As the load increased, however, the noise level increased. The three 8-in. blow-off lines had been erected through the roof and they were acting as sounding boards, providing an outlet for the sound to escape.

This problem was easily solved by fabricating mufflers, 32-in. diameter by 5 ft high, from 10-gage metal, with a 4-in. internal liner of acoustical material. These mufflers were then set over the blow-off lines.

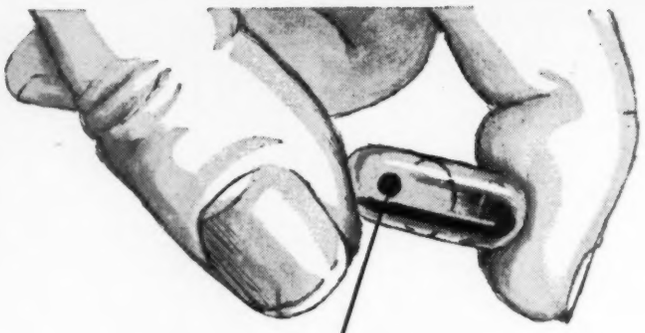
These measures completed the sound control job exterior-wise; but it had been so effective in containing the sound that company personnel could not stay inside the building to work on equipment.

Actually, the job was not yet complete. The next logical step was to insulate the piping and equipment. After careful study of the problem, it was decided to contract with a local firm to apply successive layers of 1-in. hair felt, separated by a layer of 15-lb asbestos felt. The contract was made to allow as many layers as thought necessay to be applied, with the privlege to

	MICROPHONE POSITION 1			MICROPHONE POSITION 2			MICROPHONE POSITION 3		
Freq. Band	I	II	III	I	II	III	I	II	III
30–75 CPS	80 DB	76 DB	78 DB	80 DB	74 DB	79 DB	78 DB	74 DB	79 DB
75–150	83	80	83	86	83	84	84	82	87
150–300	85	80	82	86	82	83	82	79	80
300–600	97	89	85	97	88	85	91	87	82
600–1200	101	83	82	102	84	84	99	80	80
1200–2400	105	82	83	107	80	81	103	78	79
2400–4800	103	81	80	104	78	78	100	75	75
4800–12000	94	78	75	95	76	73	90	71	68
Loudness (Sones)	612 S	223 S	207 S	638 S	200 S	195 S	547 S	162 S	155 S

	MICROPHONE POSITION 1			MICROPHONE POSITION 2			MICROPHONE POSITION 3		
Freq. Band	I	II	III	I	II	III	I	II	III
30–75 CPS	77 DB	73 DB	79 DB	77 DB	75 DB	78 DB	76 DB	73 DB	76 DB
75–150	82	80	85	83	81	85	80	79	83
150–300	86	80	85	84	80	85	88	80	82
300–600	94	86	86	93	92	88	92	89	84
600–1200	98	82	82	99	81	83	96	82	83
1200–2400	103	79	80	104	81	85	102	83	85
2400–4800	100	75	76	101	81	84	99	82	84
4800–12000	91	70	69	93	78	79	90	79	78
Loudness (Sones)	648 S	172 S	176 S	557 S	221 S	249 S	509 S	233 S	237 S

NOTE I. 10 Dec. 1952 — No covering on any of the Equipment.
II. 19 Dec. 1952 — Two layers of 1" hair felt and three alternate layers of 1516 felt.
III. 20 Feb. 1953 — As 19 Dec. with cloth and asbestos cement added.
It is felt that the difference in the data taken on 19 December an l 20 February was due to a heavier load at the time the readings on 20 February were taken.



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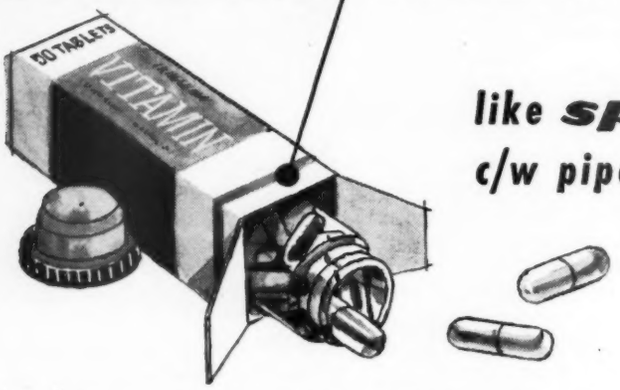

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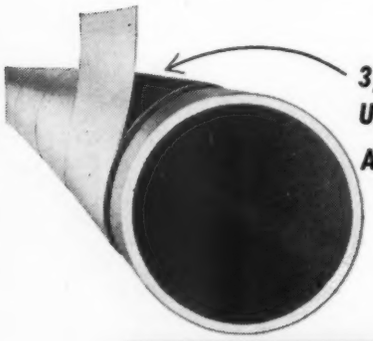
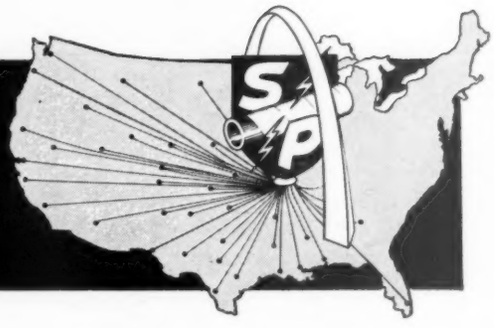


3/32" MINIMUM ENAMEL UNDER THE WRAPPER AT spi

THROUGH FREIGHT RATES AT THE ST. LOUIS GATEWAY



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stop after one layer. Application of a finish coat of asbestos cement and 8-oz canvas would complete the job.

To ascertain the effectiveness of the soundproofing job, readings were taken on three different days. These readings are shown in the table. On each date, six readings were made in eight frequency bands. The readings were made in decibels representing the sound pressure level in each frequency range, with a standard decibel reference of 0.0002 dynes per square centimeter.

The loudness as shown, is in *sones*. A *sone* is an arbitrary scale based on what noise sounds like to the ear. A noise with a *sone* rating of twice another noise, sounds twice as loud.

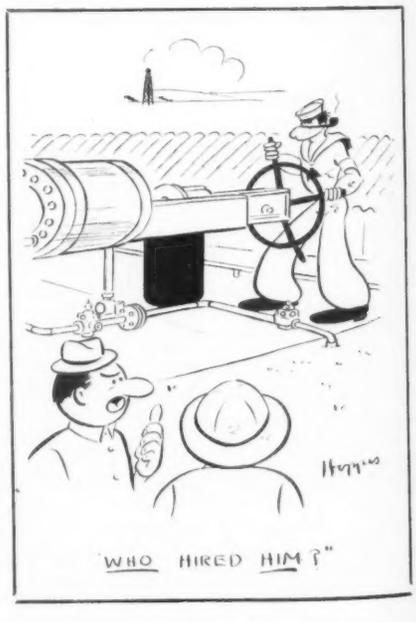
The location of the microphone used in taking the readings is shown in Fig. 1. In all cases, it was held approximately 5 ft from the floor.

Reduction of the noise in the last four frequency bands (600-12,000 cps) was the chief problem. These four bands are important because they cause loss of hearing, make it difficult to talk, and are very annoying. In these bands, the work was very successful.

This was the first experiment made by Lone Star in sound control. Since that time, another pressure reducing station has been insulated, as a result of noise complaints.

It was an existing station of standard construction and no attempt was made to insulate walls or ceilings or other portions of the building.

In this station, the treatment of using 1-in. hair felt and 15-lb asbestos felt, plus a final coating of asbestos cement and canvas, was used. Although no noise survey was made, the reduction of the sound level was very perceptible to the human ear and there have been no further complaints. * * *



Cathodic protection, inhibitors, and proper design will help solve most

Compressor Station Corrosion Problems

J. C. Berringer,
Chief Corrosion Engineer,
Panhandle Eastern Pipe Line Company
Kansas City, Missouri

EXPERIENCE HAS INDICATED THAT although there are various corrosion problems involved in maintenance of compressor station engines and appurtenant equipment, there are only a limited number of such corrosion problems that cannot be remedied or corrected by the application of cathodic protection, use of corrosion inhibitors and water treatment, or proper design and selection of metals in corrosive environment. There has been a rapid increase in the application of cathodic protection to provide protection to surfaces exposed to corrosion.

There are various types of corrosion in compressor station equipment, and each is influenced by different environment and factors. It is essential that the cause and type of corrosion or metal loss be accurately identified before corrosion mitigation measures can be applied that will provide the desired results.

Corrosion Due to Cooling Water

Equipment using the open water system for cooling presents a major problem to provide cathodic protection to those metal surfaces exposed to circulating water in the power pistons and jackets. The application of magnesium anodes in various shapes is required. The main factor to be considered in the design of such installations is the type of water encountered.

Magnesium anodes in the various shapes now available qualify this type of cathodic protection for equipment where the complex physical shape of the equipment to be protected prohibits other type of cathodic protection. It is essential that sufficient space be provided between the placed anode and adjacent structure so that interference to fluid flow will not impair operation of the equipment.

The various shapes in which magnesium anodes are supplied provide a means of installing galvanic anode material in the immediate area of the surface requiring cathodic protection. This is a prime factor that has resulted in the numerous installations of this type of cathodic protection for compressor station equipment.

Cathodic protection with impressed currents is limited, due to area available for anode material. The hazard of this type of installation in the compressor station building should be considered before such an installation is made.

Corrosion in the water jacket of the power cylinder has been reduced or eliminated by the installation of magnesium slabs mounted on insulating pads and attached to the jacket wall. The current output of the anodes should be limited to the desired value, which will permit anode replacement at the time of scheduled engine overhaul.

The anode current output can be limited by the use of resistor washers, which are available in various values of resistance. They are installed under the stud bolt used to attach the magnesium to the surface to be protected. The stud bolt head and resistor washer must be protected by filling the recess in the anode with sealing compound.

Cavitation and Impingement Corrosion

Magnesium ribbon has been used in the power piston rods to reduce metal loss. Such installations, however, are difficult to maintain. Metal loss at the water discharge end of the power piston rod has in many cases been the result of cavitation erosion.

This particular type of metal loss has been reported and observed at other numerous locations and occurs when the liquid pressure falls below the vapor pressure of the liquid and vapor pockets or bubbles form. As the bubbles are carried to the area of high pressure, they collapse. Erosion is then caused by the collapse of the bubbles, and these highly localized pressure pulses result in pitting and claw-like corrosion.

This type of corrosion has been reduced when the pistons are overhauled and the orifice for water in the center of a new piston is rebuilt to the correct size.

During the service life of a piston, this orifice becomes enlarged and the increased velocity of water flow, due to the enlarged orifice, increases cavitation erosion at the location near the end of the power piston rod. When the orifice diameter is correct, the proper quantity of water flow is obtained and

the reduced water flow results in a proportionate decrease in cavitation erosion.

Cavitation can also be reduced or eliminated by increasing water pressure, improving design to reduce liquid pressure differential, and also coating of the exposed surface with a hard alloy.

Impingement attack or metal loss associated with the turbulent flow of a liquid results in smooth, rounded pits that are often undercut on the downstream side. This type of metal loss can also be reduced or eliminated by improved design to reduce turbulence or by coating the surface of the metal with a hard alloy.

Aftercooling Coils

Failure due to the corrosion of the coils and tanks of the compressed air aftercoolers at the compressor station has presented a problem in corrosion mitigation. A protective coating applied to the coils would reduce the heat transfer and effectiveness of the operation of this equipment. Replacement of such equipment is also very difficult.

Immediately after the air is compressed, it is passed through aftercooling coils that are installed in tanks through which water is circulated to provide a means of heat transfer. Due to the elevated temperature and corrosive conditions present, the application of cathodic protection is required to maintain this equipment in service.

The cathodic installations in the aftercoolers in tanks approximately four feet long, one foot wide, and two feet deep consist of three extruded magnesium rods, one and one-half inches in diameter and suspended in the tanks on one foot centers between the coils. They extend within two inches of the bottom of the tank. The magnesium anodes are connected by suitable conductors to the air aftercooling coils and tanks. Average anode life is approximately nine months, and replacement of anodes requires a minimum of labor.

These magnesium installations have been very satisfactory and have provided the necessary cathodic protection, thus eliminating failure of this equipment due to corrosion.

Water Tanks

The elevated water tanks at the compressor stations are subject to corrosion and are very difficult to repair. Previous to application of cathodic protection, the usual procedure was to clean and repaint the interior of such tanks each year. In addition to the cost of labor and material to perform this work, the station operation was impaired during the time necessary to have the tank out of service.

Adequate cathodic protection can be applied to such tanks by the installation of a rectifier and anode system. To protect tanks of 75,000-gal capacity, five metal anode rods are suspended from the roof and insulated from the tank. They are distributed in the tank in a circular design approximately four feet from the tank wall and extending to within two feet of the tank bottom.

If junk iron rods are used for anode material, each ampere of current discharged requires 20 lb of anode material. It is difficult to install a quantity of junk iron sufficient for more than one year of service. The use of aluminum anodes or anode rods of other material may be substituted, however, and the life of such anode material may be extended to three or four years, depending upon the requirements of the company opearting such equipment. Aluminum anodes of sufficient quantity to provide three years' service have been very satisfactory.

The use of junk iron for anode material is now being replaced by Duriron in these elevated water tanks. Duriron is a 14.5 per cent silicon cast iron that is very dense, hard, and resistant to electro-chemical attack. Machining of this metal is very difficult, and it must, therefore, be cast into the desired shape. At present, it is available in various diameters and all are sixty inches in length. If Duriron rods are to be joined together to provide greater anode length or electrical connections are required, inserts can be cast into the anodes or the anodes can be brazed.

Due to the low metal loss per ampere per year as reported by the manufacturer, the present five anode system could be replaced by one Duriron anode one inch in diameter and ten feet long. To provide a suitable current distribution in the tank, however, an installation of three anodes in each tank is planned. This should provide anode material sufficient for a considerable period of operation, as present data indicates that at a current density of one ampere per square foot of anode material, the metal loss is negligible in waters with pH of 7 to 10.

Average station operation prevents the formation of ice in the tank, which would damage anodes as water elevation of the tank fluctuated; therefore, the installation of anodes that provide more than one year of service is satisfactory on such equipment.

The rectifier unit to provide the cathodic protection of these tanks should be of capacity or d-c output of 14 v and 10 amp and may be mounted on one leg of the tank. The current requirements vary from four to eight amp for a 75,000-gal tank, depending upon water analysis.

Adequate cathodic potection can be provided to the tank by the above installation. The riser pipe, however, may not have sufficient cathodic protection near the base of this structure. A magnesium anode may be placed at the bottom of this pipe on an insulating pad and the magnesium lead connected to the base of the pipe riser. This will provide the necessary cathodic protection, and the quantity of magnesium may be increased to provide cathodic protection and replacement not required until the regular maintenance program includes inspection of this equipment.

Hydrogen Sulfide in Gas

Experience due to corrosion resulting from hydrogen sulfide content in the gas is related by A. K. Hegeman[1] in the replacement of corroded copper valve seals and valve cover gaskets in compressor cylinders.

Because cylinder walls, pistons, piston rings, piston rods, rod packing, and discharge valves are usually well coated with lubricating oil, sulfide corrosion of these parts is very seldom encountered in compressor cylinders. If the gas being compressed, however, is very high in sulfide content, it is advisable to use more lubricating oil than is generally considered good practice.

The main difficulty in the compressor cylinders is with gaskets and intake valves. The gasket problem is easily solved by using soft iron or aluminum instead of copper or its alloys.

Protection of the intake valves is easily accomplished by injection of lubricating oil or gas oil into the gas stream just before it reaches the compressor cylinders. The oil coats the intake valves and protects them from the effects of the corrosive gas. When flushing oil is used for this purpose, it is probably advisable to use a heavier lubricating oil for the compressor cylinder than would ordinarily be used.

Corrosion resulting from hydrogen sulfide in the gas appears to increase with increase in pressure.

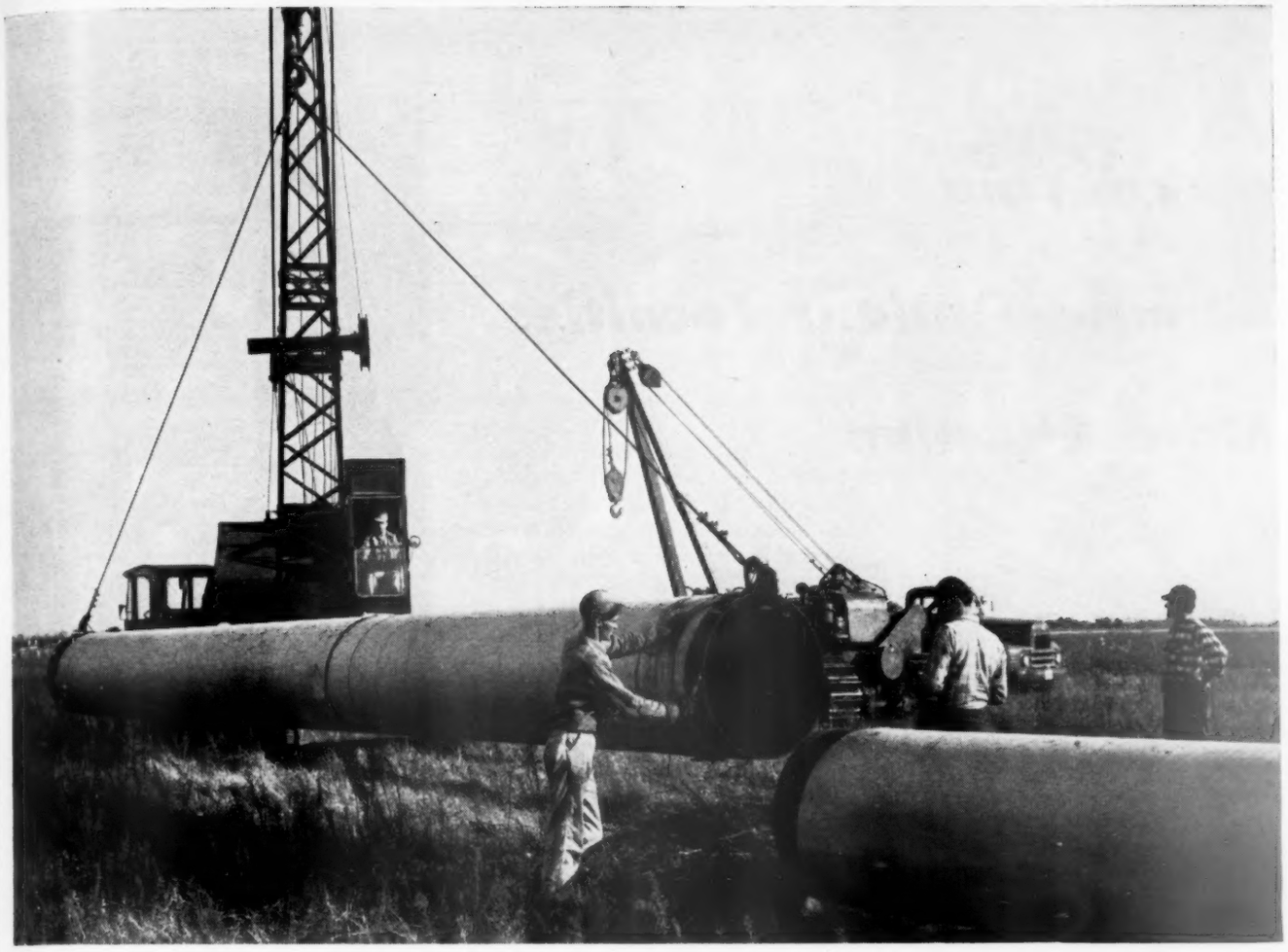
Presence of an appreciable quantity of hydrogen sulfide in the fuel gas will prevent satisfactory engine operation. An acid sludge is formed in the crankcase and acid attack on the entire combustion area of the engine is experienced. Vapor-phase cooling also has been used to remedy this condition.

Acknowledgment

This article was originally presented at the Gas Supply, Transmission, and Storage Conference, American Gas Association, May, 1955, Pittsburgh, Pennsylvania.

* * *

[1]A. K. Hegeman, "Frequent Causes of Corrosion in Gas Engines and Compressors," *Gas* (January, 1952).



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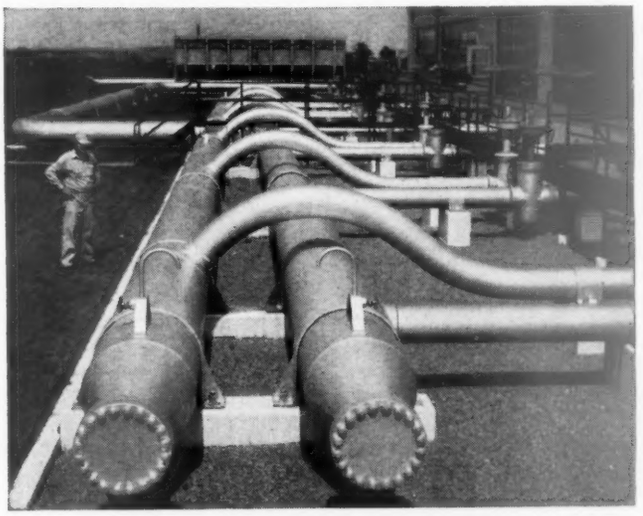

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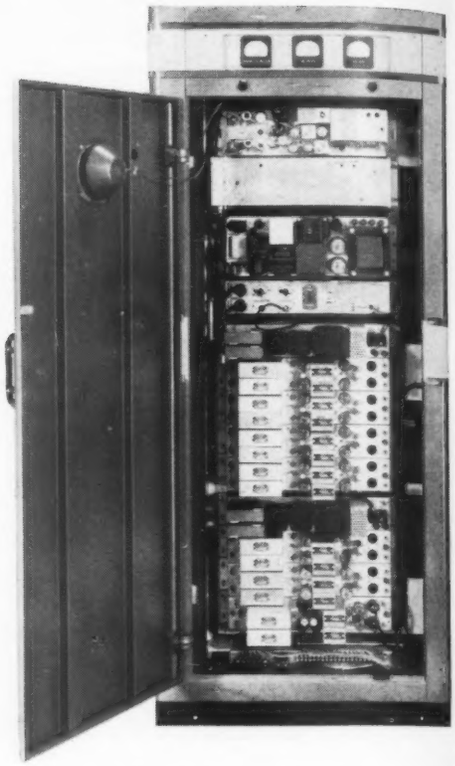


Voice frequency carrier transmitter and receiver in swinging rack cabinet with VHF radio.

H. C. Waterman

WITH the growing trend toward remotely controlled installations, centralized dispatching and automation, communications has become more and more important to all branches of the petroleum industry. Control of remotely located gathering, transmission, distribution and processing facilities demands rapid and reliable performance of the communications equipment not only for efficient control, but also for protection of the capital equipment, life and property involved. These characteristics are of particular importance to pipe lines where the need for adequate facilities may extend over a distance of 1000 miles or more. While microwave, two-way radio, and wire lines all are in use today, they are not necessarily operating at their full potential capacity.

To maximize the use of communications facilities, it becomes necessary not only to make use of the total number of channels available, but also to combine as many signals as possible on each channel. Voice frequency carrier is the practical method of combining many data signals on channels not yet loaded or on channels already carrying voice to optimize the use of the facilities available.

EXCLUSIVE

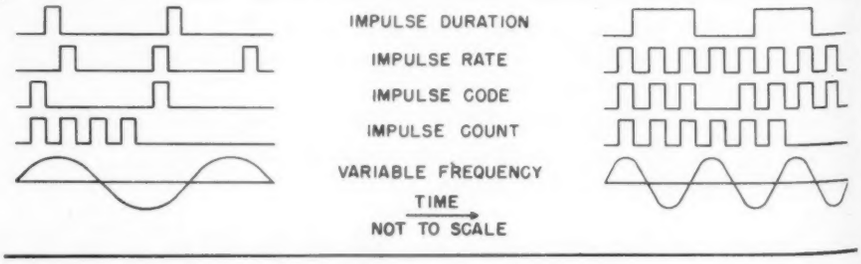
Multiplexing

Maximum reliabilty and dependability with minimum cost and complexity are achieved in combining data signals on audio channels with equipment being manufactured today. As prospective users discover its potential value, new ways are discovered to apply this versatile communications tool.

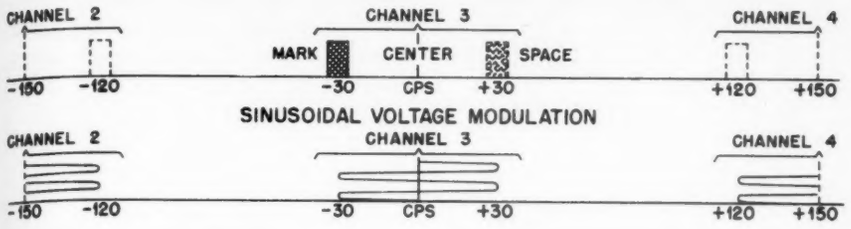
The frequency-shift voice frequency carrier utilizes the non-critical upper portion of the voice frequency spectrum (2400-3100 cps) to combine up to 5 data signals with voice signals on a single voice frequency circuit without mutual interaction. By using the entire audio spectrum for VF carrier alone (500-3100 cps) a total of 18 VF carrier signals can be combined on a single voice frequency circuit. This voice frequency circuit can be transmitted via any conventional communications media—wire line, VHF or UHF radio or microwave or any other medium or combination of media which is relatively distortionless. No special adaptations are necessary and DC circuit continuity is not required.

Applications

Wherever information can be translated into the form of coded signals and wherever data must be carried between controlling and controlled points, VF carrier has an application. A single VF carrier channel can convey the signals from a remotely located telemetering instrument to an indicator or recorder at the control point. Or, it can be used to multiplex administrative tele-



Telemetering coding schemes.

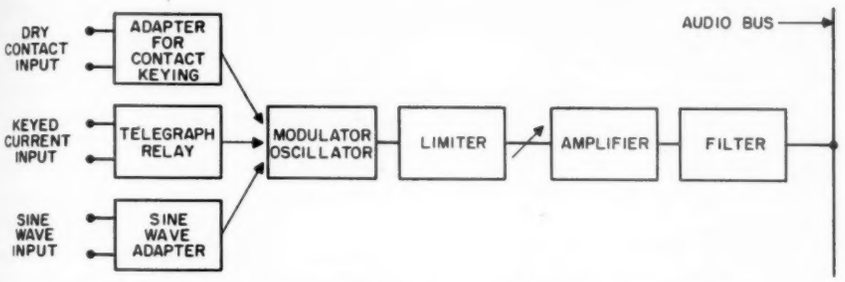


Frequency-shift VF carrier spectrum contact keying.

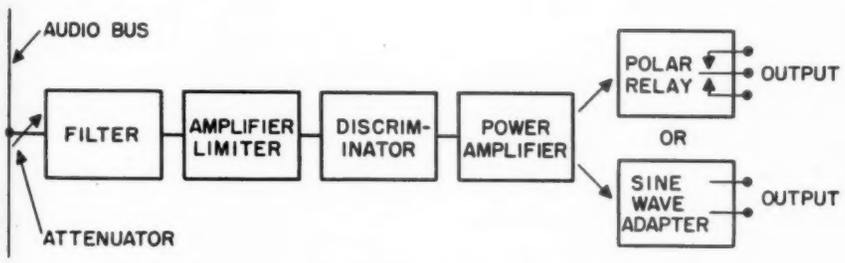
printer (or telegraph) signals onto the voice channel, providing essential communications to supplement voice. Or, same single channel may be user for "on-off" type or "increase-neutral-decease" type remote control signals.

In combination with a voice circuit, a VF carrier channel can carry dialling or signalling information for a telephone circuit when the communications medium is incapable of carrying these signals in their original form.

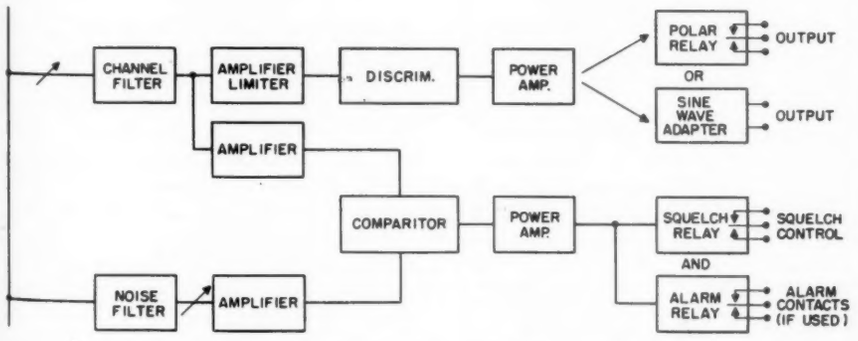
This versatile product has application wherever data must be transmitted between central offices or between control points and unattended stations in oil and gas gathering, transmission, distribution, and storage activities.



Block diagram of one channel of a dual channel transmitter chassis with input adapters.



Block diagram of one channel of a dual channel receiver chassis with input adapters.



Block diagram of master squelch receiver.

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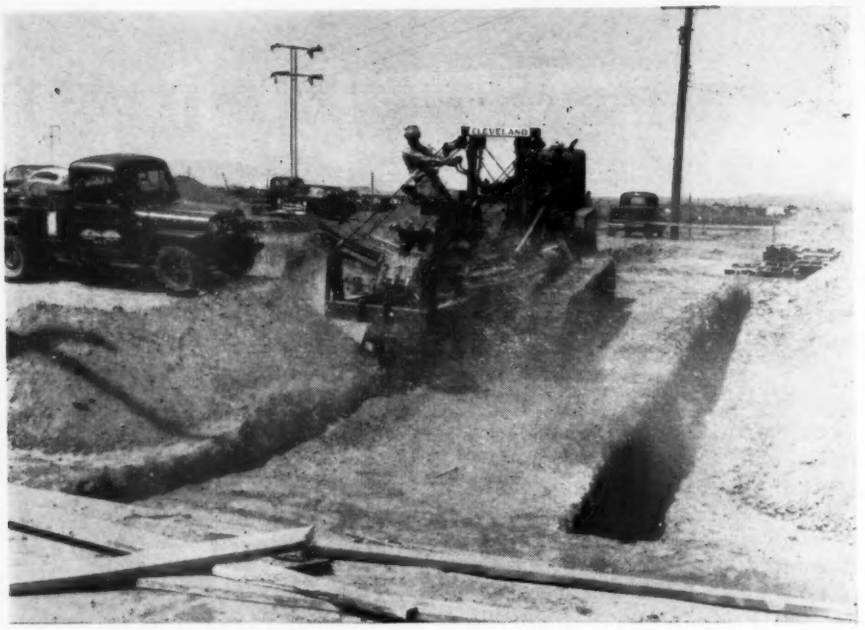

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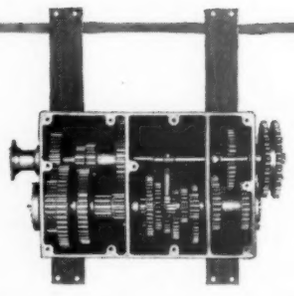

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Telemetering

Metered quantities at remote points are readily conveyed to and displayed at control points through telemetering via VF carrier. Typical of its uses are metering of:

Hydraulic
- Pressure
- Flow
- Level

Electrical
- Watts
- Vars
- Volts
- Amps
- Frequency
- Watt-hours

Mechanical
- Temperature
- Position
- Velocity
- Acceleration
- Stress
- Strain

The telemetering instruments, in general, translate the measured data into a pulsed or sinusoidal voltage in the sub-audio (0-35 cps) frequency range. For transmission via a voice channel, this type of code must be transformed into a code at voice frequencies.

The output of a telemetering transmitter and the input to the corresponding telemetering receiver generally will be in one of the following forms:

Impulse Duration. Metered data is proportional to pulse length in a system employing pulses at a constant repetition rate.

Impulse Rate. Metered data is proportional to pulse repetition rate in a system employing pulses of constant pulse length.

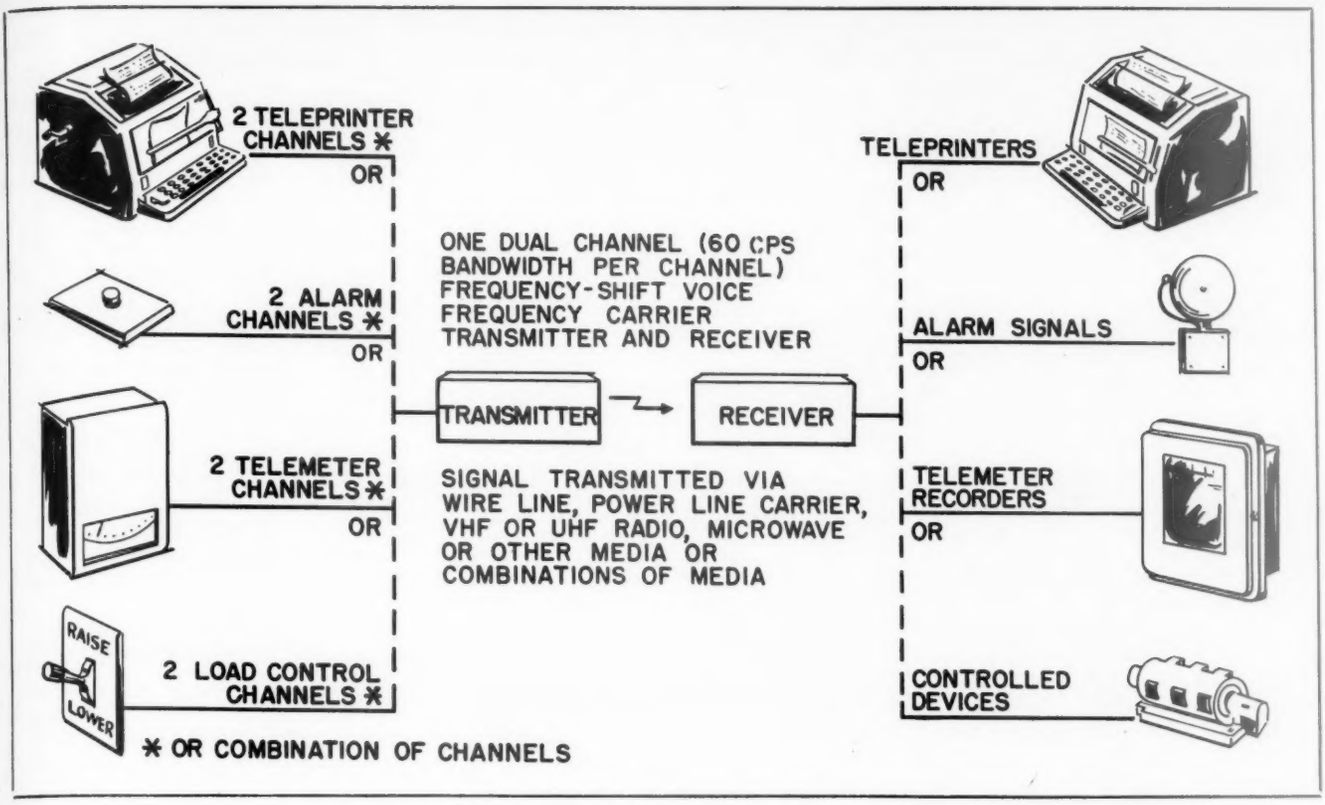
Impulse Count. Metered data is indicated by the total number of pulses per reporting time interval in a system employing pulses of constant pulse length at a varying repetition rate.

Impulse Code. Metered data is indicated by code signals consisting of specific configurations of pulses with spaces between pulses.

Frequency. Metered data is proportional to the frequency of a sub-audio sinusoidal voltage (within the 0-35 cps range).

In impulse type telemetering, the data can be in the form of open and closed contacts or in the form of on-off or reversed current keying. Frequency type telemetering provides a low level sinusodial voltage, varying in frequency.

Voice frequency carrier converts all of these types of signals to frequency modulated sub-carriers in the audio frequency spectrum, transforming them back to the original form at the receiver.



Utilization of a dual channel.

Selective Telemetering

Where a large number of quantities are to be telemetered, yet the requirements do not demand continuous operation of each telemetering circuit, additional audio spectrum conservation can be realized with selective telemetering. One VF carrier channel can serve a number of remote instruments as long as only one instrument on the common party line is reporting at one time. Only the instrument observing a change in status need be reporting. When selection of an operation is accomplished by supervisory control, selection of the appropriate telemetering instruments can be simultaneous.

Through use of the VF carrier equipment, however, degrees of freedom (*increase-neutral-decrease* type) the selection as well as the reporting can be accommodated on a single VF carrier channel. Use of this type of facility permits "interrogation-reporting" operation without the need for priority or timing equipment needed in timed report cycle operation.

Telegraph-Teleprinters

Both manual and automatic forms of telegraph and teleprinter communications systems produce a code wherein information is transmitted via combinations of pulses and spaces. The code is generally in the form of open and closed contact or pulses of current, either on-off pulses or reverse current pulses. When VF carrier is employed, the pulses become modulated audio sub-carriers, many of which may be transmitted via voice frequency circuits and restored to the original form at the receiving terminal.

Remote Control - Flow Control

For simple on-off remote control, VF carrier can provide the same degrees of freedom as required for telegraph, teleprinters and impulse telemetering where the input and output signals are simply open or closed contacts. For flow control, such as may be used to operate reversible motors of flow controllers in unattended compressor or pumping stations, three degees of freedom are provided. In this case, a single VF carrier channel provides the "increase-neutral-decrease" signals required for dependable control functions.

Supervisory Control

Since some forms of supervisory control are based on a pulse count or pulse code system, VF carrier can be readily employed to convey these code signals via any available transmission media or combination of media, eliminating the requirement for DC circuit continuity.

Dialing and Signaling

Conventional telephone circuits rely mainly on DC circuit continuity for transmission of dialing impulses and some forms of signalling functions. VF carrier performs the function where such DC circuit continuity does not exist or where facilities are not provided in the medium of transmission. It can be multiplexed on the same voice channel as the voice signals, providing the switching functions at the remote terminal for dialing and signalling.

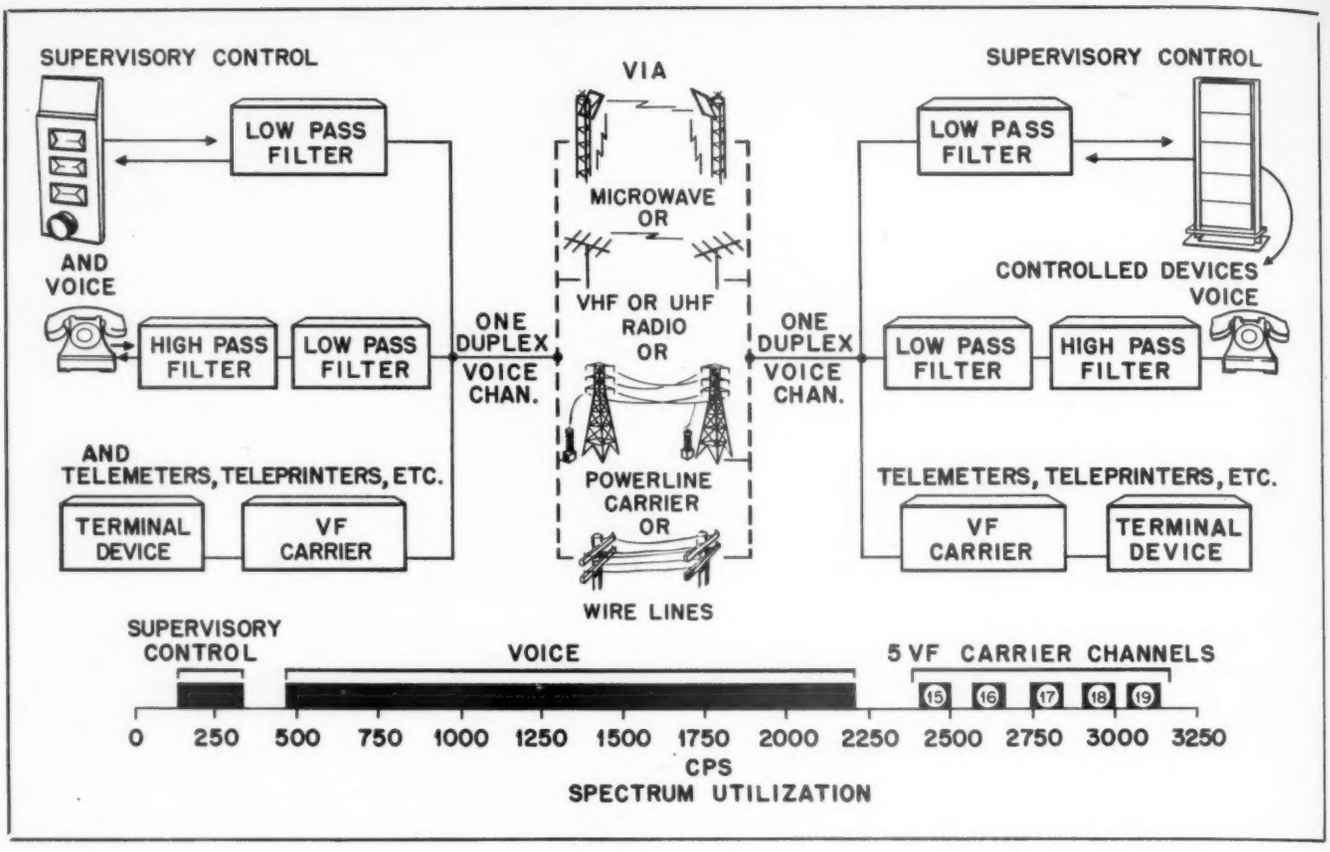
Alarms

An alarm signal indicative of abnormal, undesired, or dangerous conditions can be transformed into an on-off switching function for transmission via VF carrier to controlling or operating points. Such alarm functions as engine failure, pump bearing overheating, trespass at unattended locations, loss of communications facilities, switch-over to emergency power sources, and similar situations are readily accommodated.

Frequency Shift

Three basic types of operation, all FM or frequency shift techniques are employed. Impulse type telemetering, teleprinter operation, telegraphy and remote control all employ an audio tone 30 cps above the assigned VF carrier channel center frequency for the "off" or "space" signal. For the "on" or "mark" signal, the frequency is shifted to 30 cps below assigned center frequency.

In flow control systems, the signal is normally at rest ("*neutral*" position) at the channel center frequency. For "*in*



Spectrum utilization.

crease" signals, the frequency is shifted to 30 cps below center frequency and for *"decrease"* signals, the frequency is shifted to 30 cps above channel center frequency. In frequency type telemetering systems, the varying frequency telemetering signal frequency modulated the VF carrier transmitter at a deviation of ± 30 cps.

VF Carrier Components

A VF carrier terminal consists of the required number of dual-channel transmitter chassis, dual-channel receiver chassis, differential squelch receiver chassis, and all-purpose power supply chassis. The flexibility of these units adapts them to all types of installations, serving the specific requirements of any system.

Transmitters

Basically, an FM transmitter operating at audio frequencies, the VF carrier transmitter includes an oscillator circuit employing a high-Q toroid coil and selected tempertature stabilized silver-mica capacitors for frequency stability. A reactance modulator provides the required FM deviation and maximum deviation limiting without introducing amplitude modulation. A limiting amplifier and a power output amplifier complete the channel.

Channel center frequencies are spaced 150 cps apart from 525 to 3075 cps. Each channel occupies a bandwidth of 60 cps. The channel frequencies have been chosen to minimize the effects of both harmonic and intermodulation distortion.

The frequency determining elements of the transmitter are encased in plug-in assemblies, permitting use of the same basic chassis on any channel.

At the transmitter output, the plug-in bandpass filter contains constant-k sections with m-derived end sections passing the channel operating frequencies but sharply attenuating all spurious and harmonic outputs. The filter terminates the 500/600 ohm line only at the transmitter operating frequency, preventing excessive line loading and interaction between channels when several or all available channels are in use on the same line.

Each dual-channel chassis contains four tubes (two tubes per channel). All tubes are of the same type and preaged tubes should be supplied for high reliability.

For the four types of input signals, four types of plug-in keying adapters are employed. One adapter accommodates a "dry" contact keying input (open-closed switching functions). A second adapter is a polar relay to accommodate either "on-off" or "forward-reverse" current keying (either 30 ma or 60 ma keying current). A third adapter makes the proper input connections for sub-audio sinusoidal voltage modulation from frequency type telemetering instruments. A fourth adapter accommodates 3-position input necessary for flow control. By interchanging appropriate adapters, channel function can be changed as required.

Power Supply

Transmitter and receiver power requirements, both plate and filament voltages, are furnished by a single type of power supply. One power supply chassis will accommodate as many as 10 transmitter or receiver chassis, the maximum number depending upon the specific power input requirements of the chassis employed.

Input to the power supply chassis is 117, 50/60 cycles. Transformer taps are provided for normally low (105v) and normally high (125v) line voltage as well as the nominal 117 v. Metallic rectifiers are used in the plate voltage circuits.

In addition to filling the power requirements for transmitters and receivers, the power supply furnishes termination facilities for these chassis. A chassis mounted plug which mates with plugs on the other chassis provides common busses for the 500/600 ohm receiver input circuits, the 500/600 ohm transmitter output circuits, the filament voltage and the plate voltages without use of interchassis cabling.

Receivers

Like the transmitter, the receiver is a dual-channel unit with interchangeable frequency determining elements and plug-in adapters for the specific data being handled.

At the input to the receiver, a high impedance attenuator provides the connection to the 500/600 ohm line with minimum bridging loss. Following the attenuator, a plug-in bandpass filter, similar to, but more selective than, the transmitter filter, accepts all signals within the channel with less than 3 db attenuation. However, more than 63 db attenuation is provided for signals in the adjacent channel.

Four tubes are used for each channel, an input amplifier, a limiter that compensates for wide fluctuations in both signal and noise input levels, a balanced discriminator that immunizes the receiver against the effects of supply voltage variations, and an output power amplifier stage. As in the transmitter, aged tubes are supplied for reliability.

At the output, a plug-in adapter is supplied, either a polar telegraph relay or a sinusoidal voltage adapter. The polar relay furnishes the "dry" contact keying output or, with an external current source, the current keying output. With spark suppression for inductive loads, relay contacts are rated at 100 million operations at 60 ma DC. The sinusoidal voltage adapter connects the varying frequency AC voltage output to the frequency type telemeter.

For flow control applications, a neutral-seeking polar relay is used in place of the polar telegraph relay. An adapter is available to utilize a WE 255-A relay in place of the polar telegraph relay.

Squelch

For those applications where an exceptionally high degree of signal reliability is required, a differential squelch receiver can be employed. The squelch receiver chassis contains one signal channel plus the squelch circuity. The noise energy from an unused VF carrier channel (or from the entire audio spectrum) is compared to the signal energy on a channel in use.

If, for any reason, the signal-to-noise ratio falls below the present level, the receiver output circuit is blocked. The response time of the squelch circuit is ⅓ to ½ that of the signal circuit and the squelch release time is sufficient to clear the spurious signal from the receiver before restoring the signal channel to normal operation.

Spurious data is prevented from appearing at the receiver output. In addition to the squelch relay, a plug-in high speed alarm relay operating simultaneously with the squelch relay can be included on the chassis to provide a channel supervision alarm or additional squelch relay contacts where required.

The fail-safe features of the squelch circuit afford protection against unacceptable signal-to-noise ratios regardless of the cause—loss of carrier signal, loss of audio channel, loss of primary power, tube failure or any signal loss or noise increase factor.

For a group of receivers on one voice channel, only one noise filter is required. If additional channels require the squelch protection, the output of the filter is fed through the inter-chassis plugs to the other receiver chassis equipped for squelch protection.

Filters

In any application where several types of communications are carried on a common channel, voice frequency filters may be used to minimize interaction between types. For example, a 2150 cps low-pass filter is inserted as part of a telephone termination used in parallel with VF carrier. The filter blocks the energy of the VF carrier channels (2475-3075 cps) from the voice portion of the circuit. It also serves to block the higher frequency voice signal components from entering the common circuit without blocking the DC signalling functions or 20 cps, 60 cps, or harmonic ringing functions.

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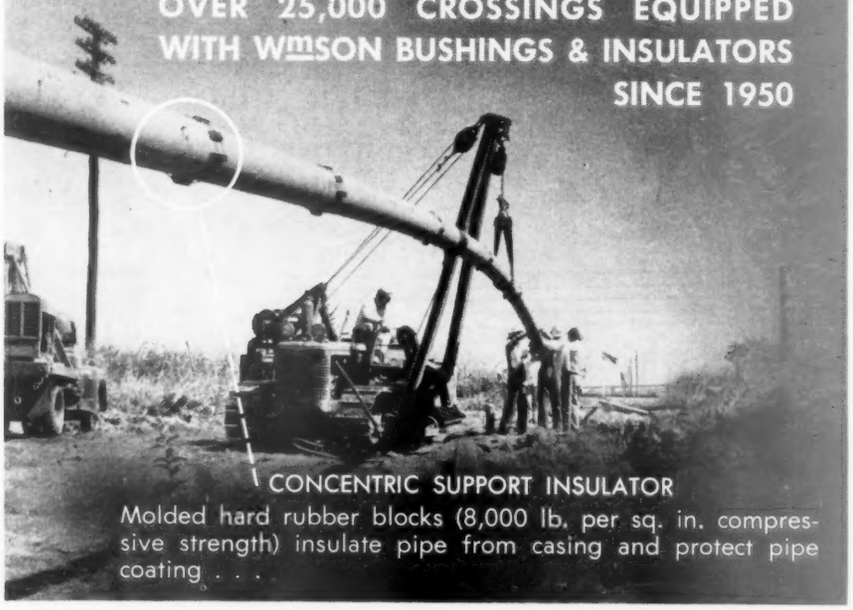

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Thus, one filter at each terminal effectively isolates the VF carrier signals from the telephone circuit signals that appear on a common circuit.

The filters include high-Q toroid coils for long life stability in both constant-k and m-derived sections. Commonly used filters are the 450 cps high-pass, the 1700 cps low pass, and 2150 cps low-pass. Filters of the same type on other frequencies are also available to meet specific systems requirements.

Cabinets

VF carrier terminals consist of the required transmitter, receiver, power supply, and filter chassis necessary to perform the functions desired.

It is generally advantageous to utilize existing rack facilities for a limited number of channels. The compact chassis (filter-1 rack unit, all others-2 rack units) fit into cabinets or on racks containing other elements of the communications system.

For larger systems employing many VF carrier channels, cabinets including desk-top, upright fixed rack, upright swinging rack, and weatherproof cabinets may be used. Open racks and switchboard cubicles can also be used to mount the equipment.

The Author

H. C. Waterman is project engineer in the utility products department of Motorola, Inc., communications and electronics division. A native of Elkhart, Indiana, he graduated from the General Motors Institute in 1941 with a degree in mechanical engineering. He worked on aircraft gun turret control and jet engine control systems until 1947, when he joined Motorola as development engineer for audio tone selective signalling systems. He holds two patents on gun turret control, two on jet engine controls, and one on selective signalling systems (plus two pending on the same topic). He is a member of AIEE and IRE.

Facilities

The medium of transmission must be capable of supplying the required communications facilities for the VF carrier. Telemetering is generally a simplex operation, i.e., data is transmitted only in one direction and no return circuit is necessary. Teleprinter operation, however, is generally a duplex function, i.e., a complete simultaneous two-way communications path must be available.

In a duplex system, a transmitter and receiver connected to a common two-wire circuit must be on different channels to prevent the local transmitter from over-riding the incoming signal in the receiver. It is possible, however, to employ adjacent channels at the same terminal on two-wire circuits that have terminal-to-terminal losses as high as 25 db.

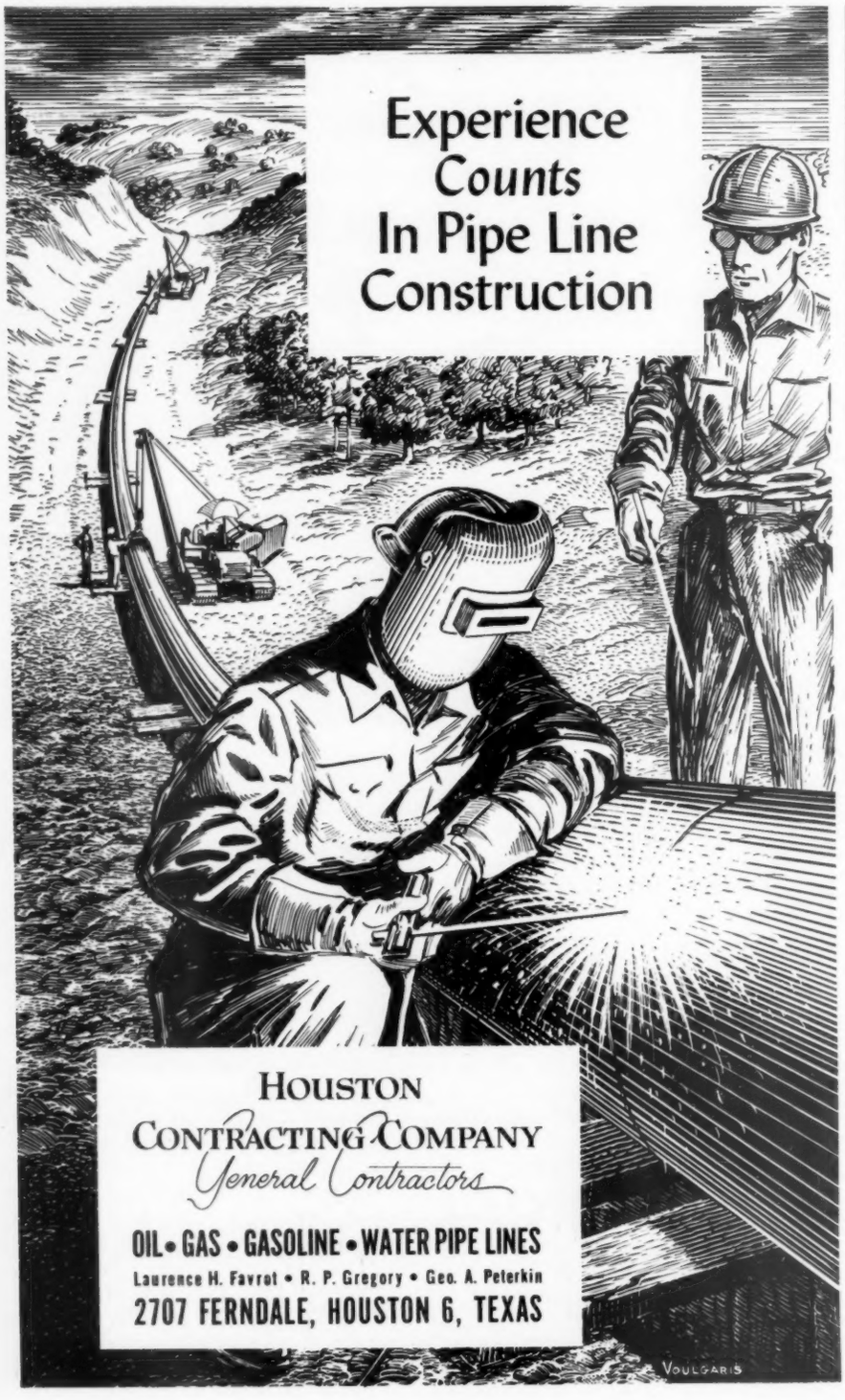
Chassis

One VF carrier channel must be provided for each continuously operating function. Since each chassis is a dual-channel unit, only one chassis is required for each pair of VF carrier channels.

If the channel is not required for continuous operation, a switching arrangement can be used to select and connect the desired terminal device to the chassis as required. For example, data from a telemetering transmitter on some controlled device may be required only when the status of that device is being changed. Hence, one VF carrier channel may serve several such telemetering transmitters as data from each is required at the control point.

In such applications, data from only one telemetering transmitter can occupy the channel at any one time.

The correct transmitter chassis, i. e., a model with the appropriate input



adapters, must be used for the data being transmitted. Dry contact keying adapters, current keying adapters, or sinusoidal voltage adapters are supplied as standard equipment. For flow control functions, a standard dry contact keying adapter used in conjunction with an application kit provides the three degrees of freedom required for increase-neutral-decrease signals on a single channel. All adapters are interchangeable if the function of the channel is changed.

In the case where only one channel of the two available is used, a chassis is supplied without one oscillator-modulator unit, one output filter, and one input adapter. Frequency determining components may be added at any time to place the channel in service.

The receiver, like the transmitter, has facilities for two complete and independent channels. Where only one channel is used, the discriminator unit, the input filter, and the output adapter are omitted from the second channel and may be added later.

A dry contact keying adapter or a sinusoidal voltage adapter are supplied as standard equipment. WE 225-A relays plus mounting kits and a mounting panel are available as alternates to the dry contact keying adapter. For single channel flow control, a neutral-seeking relay is used as the output adapter and is supplied as part of an application kit.

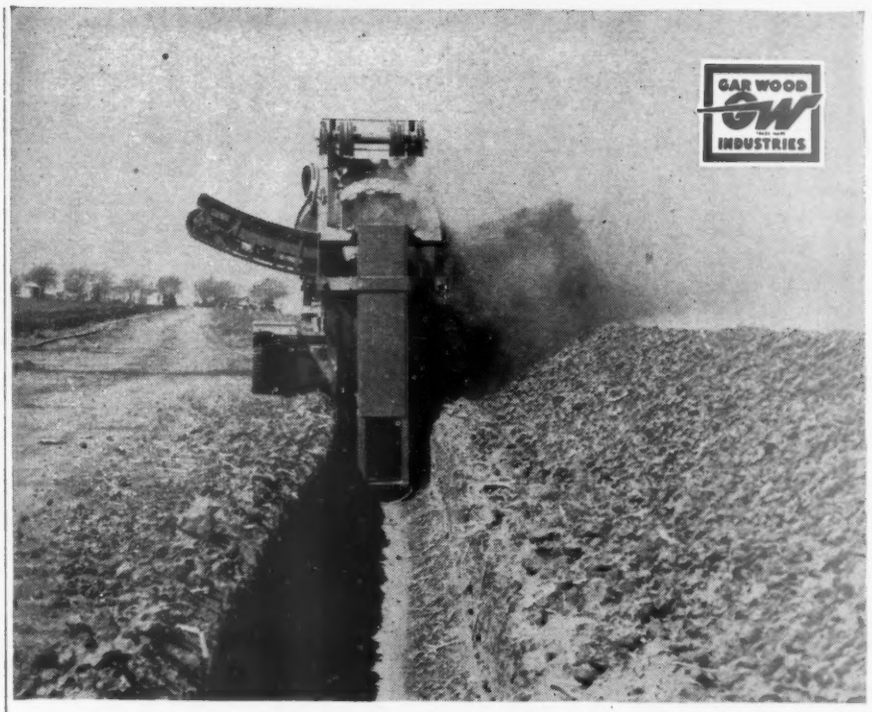
Receivers with squelch provide only one signal channel. The master squelch receiver provides the noise signal for itself and all slave squelch receivers at the same terminal on a common line.

The number of power supply chassis required for a specific terminal installation is determined by the power requirements of the transmitter and receiver chassis used. Requirements of these individual chassis must be totaled. The number of power supply chassis required can then be determined by the output capabilities of the power supply and the input requirements of the transmitter and receiver chassis.

The need for high-pass and low-pass audio filters is dependent upon the signal levels and separation between signals required. In general, isolation of VF carrier equipment from other energy on the voice frequency channel is required only when the other functions produce interfering signals on the VF carrier channels. It is usually desirable, however, to block the VF carrier signals from both voice and tone supervisory control circuits and to block voice and supervisory control signals from each other.

Systems

Any point-to-point medium of transmission that passes audio frequen-



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HYDRAULIC CONVEYOR DRIVE . . . is completely controllable from operator's seat. Provides forward or reverse belt drive in a selection of 3 speeds to meet any conveyor need. Eliminates the shock damage normally found when driven mechanically from digging wheel drive—no complicated mechanical units! . . . **LIVE HYDRAULIC WHEEL HOIST** . . . for fast, accurate positioning of digging wheel independent of all other functions. Hoist operated by simple, one-hand controls from operator's seat . . . **TRACTOR-TYPE CRAWLERS** . . . allow variation in tread width and bearing area thru selection of tread pads to suit any type digging. Idler rollers have face-type seals for longer crawler life . . . **SIMPLIFIED GROUP CONTROLS** . . . with panel mounted conveyor and hoist controls, foot operated steering controls. All controls need only light pressures, are within easy reach of opeator. Control arrangement simplifies use by experienced operators—speeds the "breaking-in" time of new operators . . . **STREAMLINED UNIT DESIGN** . . . plus standardized unit construction give both a neat, compact design and interchangeability of major components and assemblies with other new series "O" Buckeye ditchers to be announced very soon . . . **HEAVY DUTY DIGGING CAPACITY** digs to 5'6" deep with optional cutting widths from 16 to 32 inches, in 2 in. steps.

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Blue Flag wraps entire 93.64-mile extension without a break

To protect the entire Topside Bristol Extension against corrosion, Tom Brown, Chief Engineer East Tennessee Natural Gas Company, specified Blue Flag glass fiber reinforcing pipe wrap.

Blue Flag wrapped the extension's entire 93.64 miles without a break, according to Mr. Brown. He writes:

"*During construction*, the pipeline was protective-coated against corrosion. Application was a standard 3/32" minimum-thickness coating, using Blue Flag Reinforcing Pipe Wrap for reinforcing the enamel.

"The total main line was machine field-wrapped. For over-the-ditch operation, Blue Flag Reinforcing Wrap proved very satisfactory. The wrap was easy to handle, light in weight but strong, with no breakage, and porous enough to release the gases. The total cost per foot was impressively low."

Blue Flag Pipe Wrap greatly increases enamel strength; offers exceptional resistance to cracking, thereby helping to prevent corrosion; adds years to a pipeline's service life. It is made of special highly inert glass and produced by L·O·F Glass Fibers' exclusive "Electronic-Extrusion" process. The uniform porosity of the fine glass fiber mat improves enamel distribution and greatly reduces the number of "holidays."

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BLUE FLAG Reinforcing Pipe Wrap, **DURAMAT** Protective Outer Wrap, **DURAMESH** Pipeline Fabric, **DURATAPE** Pipe and Joint Wrap

cies can be used for VF carrier. This includes wire line systems, power line carrier, VHF and UHF radio, microwave, and combinations of the various media. Since VF carrier is designed for standard 500/600 ohm circuits, it can be directly coupled into virtually all voice circuits. Furthermore, since VF carrier consists of audio tones, the signals pass through the voice circuits of all media or combination of media without special adaptation.

As in any FM system, the receiver input level must be adequate to saturate the limiters to achieve maximum protection from the effects of noise. At least 50 millivolts should be available from the 500/600 ohm line at the receiver input.

Because of high degree of selectivity achieved in VF carrier and because of FM limiting action that minimizes effects of noise, extremely poor signal-to-noise ratios on input line can be tolerated without difficulty.

Spurious signal level and unusual noise effects on VF carrier channel frequency should not be overlooked. High selectivity of receiver precludes any harmful effects of noise energy outside receiver pass band. However, if sufficient spurious signal energy is present within the receiver pass band, it may exhibit the FM "capture" effect. It is recommended that a minimum ratio of 6 db be maintained between the desired signal and any undesired "on-channel" signals. These undesired signals may be produced only by inter-modulation distortion, harmonic distortion or unusual noise effects within the medium of transmission. VF carrier transmitters cannot produce the interfering signals in themselves even when all 18 channels are in full operation.

Single sideband or suppressed carrier systems in the communications media are capable of producing an undesired shift in the frequency of transmitted intelligence. VF carrier is not recommended for use in any non-synchronized system that produces a tone frequency shift of more than 1 cps.

Frequencies

A total of 18 VF carrier channels are available for any voice channel. If the full voice frequency spectrum is available, any channel or combination of channels may be used. If unusual noise or interference signals are present at specific frequencies, however, channels or other frequencies are, of course, preferred. If voice is present on the channel, the top 5 VF carrier channels are used. It is also possible to limit the voice frequency at approximately 1700 cps and employ up to 8 channels.

The choice of the noise channel should be the frequency at which the random noise is the greatest. * * *

FIG. 1. Overall picture of the job.

P 624

Control Fire Method for Gas Pipe Line Repair

Harry W. Gavin
Transmission Pipe Line Supervisor,
Southern Counties Gas Company of California

When it Becomes Necessary to Cut Gas Lines, Work must be done under conditions that assure no explosive mixture. This can be done in any of three ways: By isolation of a section, accompanied by a complete purge; by filling the isolated section with an inert gas, or by leaving the line filled with gas and controlling the amount of "leakage" through the open cut by means of a valve and blowoff stack installed at the job location. This last method is called "Fire Control."

In 1947, when operation began on the California section of the "Biggest Inch Line," the majority of the men had little or no experience in transmission pipe line work. This presented quite a training problem, especially so when it was necessary to replace several short sections of line in the first few months of operation. At this time, Southern Counties Gas Company adopted the "Fire Control" method of cutting out and replacing these sections.

In order to train the men as soon as possible, the company started the practice of writing a job outline or procedure and making schedules of all planned jobs. These write-ups were given to the men as preliminary work was being performed. On the day before the shutdown, there was a final get-together to discuss the complete job and answer any questions the men might have.

By doing a great deal of pre-job planning, it was possible to reduce downtime to a minimum. This was especially impor-

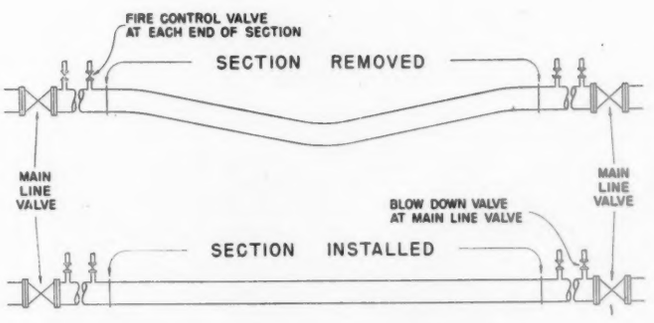

FIG. 2. Sketch of the job showing the section of pipe removed, and the section installed. It also shows the main line and blowoff valves—in this case located about 6 miles apart—and the 4-in. fire-control valves at the job location. These valves were installed about 4 ft from the cuts.

FIG. 3. The 4-in. fire-control valve assembly. This includes the pad, a 4-in. half coupling, a 4-in. by 4-in. nipple with a ¼-in. outlet, and the 4-in. fire-control valve and stack. The ⅜-in. tubing connected to the ¼-in. outlet is connected to a natural gas cylinder located on top of the bellhole, about 25 ft away. If the fire gets too low, gas can be added from this cylinder (the same size as a K oxygen cylinder) to keep the gas burning on the outside of the line.

FIG. 4. Single cut being made and a man mudding the cut behind the cutting torch. Mud is used to cut down on the amount of fire the welder has to contend with and also to conserve gas if the shutoff is near 100 per cent.

tant the first few years, when there was only a single line operating.

This method has worked so well that it has been adopted as standard procedure.

The sketch, job write-up, schedules, and pictures shown in this article are from a job performed on May 8, 1955. This job was performed by the crew that has had the least amount of experience of any crew in our division; in fact, this was the first replacement made in that district in about five years. During that time, there was a complete change of personnel in this crew except for one man, so this was the first replacement job for four men, including the foreman. Under these conditions, without a lot of pre-job planning, the only part of the job to have been well organized would have been confusion.

The job was to remove 168 ft of 30-in. pipe. In this section of pipe, there were 6 overbend and 5 sag wrinkles. The replacement section was straight pipe. This raised the line approximately 4 ft to allow a flood-control pipe to cross under our line.

From this point on, the article has been written so that anyone desiring to adopt this method could follow the instructions outlined and be able to use the "Fire Control" method without encountering difficulties.

It has been our experience that it is necessary to prepare a job write-up for each job. Although two jobs may appear similar, local conditions will require changes in the write-ups.

The typical write-up includes five parts, as follows: (1) Preliminary work, (2) notifications, (3) valving operations and blowdown, (4) remove section of pipe, and (5) install new section of pipe and return the line to service.

This method can probably be explained best by reviewing each step of the write-up, a section at a time.

1. **Preliminary work to be performed before the shutdown.**
   a. Do necessary excavating. *Excavate as required by local conditions.*

FIG. 5. Before installing the outside line-up clamp to finish the last 6 to 8 in. of the cut, the line is wrapped with wet canvas to extinguish the fire. (The 4-in. fire-control valve is closed during this operation or when adding gas.)

FIG. 6. After the fire has been put out, the line is cooled and the excess mud washed off. Two to three thicknesses of 3-in. wide friction tape are placed over the cut except at the uncut part on top of the line. The outside line-up clamp is installed and the cut completed. In this case, the line pulled apart about 1 in. The clamp keeps the pipe from jumping up or going out of line, and the tape limits the fire to the short section on top of the line. This is easily extinguished with a DuGas extinguisher.

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FIG. 7. After the cut has been completed. The fire has been extinguished, the clamp removed, the cut wrapped with canvas, and the banding tape is being installed.

FIG. 8. The third cut being made. In this case, the 4-in. fire-control valve is about 80 ft away.

b. Make up new section of pipe and apply coating.

c. Purge new section with inert gas the day before the shutdown. *Purge as required by company policy. In our company, we purge sections more than 40-ft in length. Any inert gas can be used and the ends of the pipe sealed with nightcaps. We purge by installing 1½-in. flexible tubing from the exhaust pipe on an air compressor to a nipple installed in the nightcap. After the air is purged from the section of pipe, the ends are sealed with the nightcaps.*

d. Install and hot-tap 4-in. fire-control valves. *See Fig. 3.*

e. Clean wrapper off where cuts will be made.

f. Grind the longitudinal seams where bands will be installed. *This is necessary only if bands are to be used.*

g. Fit bands on the line. *Fitting the bands to the line where they will be installed will save time during the shutdown.*

h. Mark the line for cuts.

i. Install blocking if necessary.

j. Lubricate and operate main-line valves upstream and downstream of job location. *Lubricating and operating valves will insure a more positive shutdown and reduce the amount of gas to be controlled at the job location.*

k. Install a temporary ½-in. by-pass line at upstream main-line valve. *This was a local requirement to purge the exhaust gas from the 168-ft section as it was being installed.*

l. Test radios the day before the shutdown. *This was done to be sure all units were operating. If not, time still remained to have them repaired.*

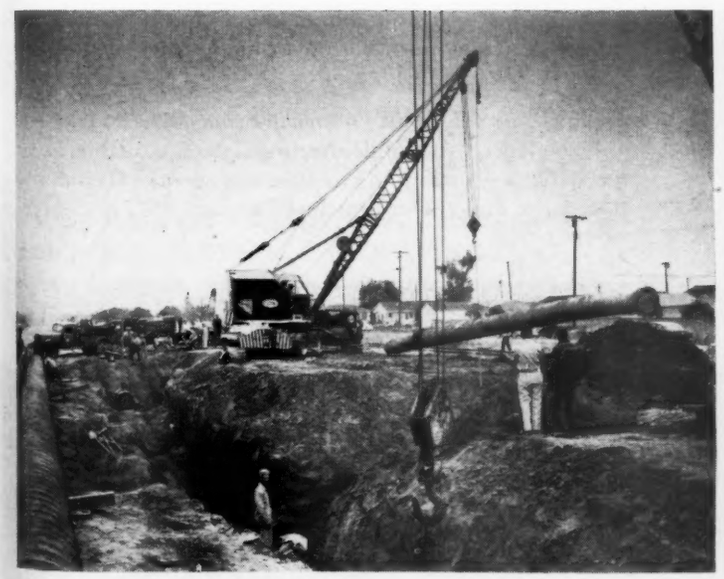
m. Turn off cathodic rectifier (located nine miles upstream) before blowdown. *The rectifier was taken out of service to reduce electrical current on the pipe line—a safety measure.*

2. **Notifications.**

a. Notify the CAA, La Habra and Whittier Police and Fire Departments, State Forestry, and the county sheriff's

FIG. 9. Nightcaps are installed to keep the line filled with gas and to serve as a safety measure as the old sections are being removed.

FIG. 10. End of the pipe is covered with wet canvas (three thicknesses) and banded into place. The nightcap has been removed. Later, the new section will be purged against this canvas.



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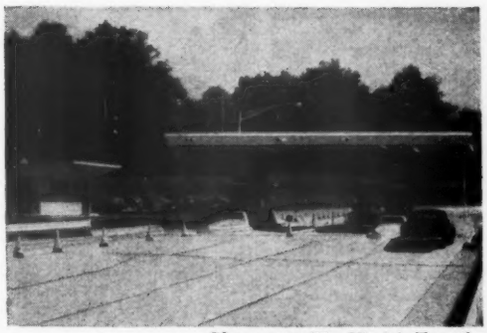

Photo courtesy West Virginia Turnpike

PIPELINES use Philco microwave for automatic operation. At this control center, pressures and flow rates of oil, operation of pumps, compressors and telegraphic printers, throughout this 1000-mile pipeline, are monitored and automatically controlled. Duplex voice communication is provided from one location to another.

Photo courtesy Platte Pipe Line

RAILROADS prove Philco microwave dependable. Philco microwave has proved to be a reliable and dependable means of communication, even during floods and storms when vulnerable wire lines have failed. Voice communication, telegraph and teletype are transmitted instantly to remote stations along the route.

Photo courtesy Santa Fe Railroad

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FIG. 11. Bond cable installed to the new section. Both ends are bonded. The nightcaps on this end will be removed before the pipe is lined up to install the band.

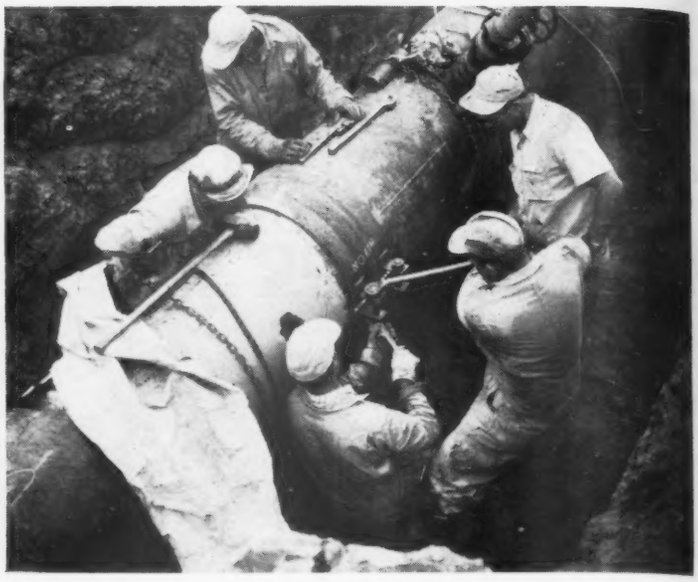

FIG. 12. Band being installed. When this operation has been completed, the edges and the horizontal edges where the bands connect will be sealed with 2-in. or 3-in. friction tape.

department regarding shutdown and blowdown time.

b. Notify people living in the area around Valve No. 25. *The CAA (a and b above) is requested to issue an order for airplanes to avoid the blowdown area or stay at a high altitude. City and county officials as well as the people living in the area are notified so that a public relations problem will not be caused by the blowdown.*

c. Notify the local distribution division to turn off and relight customers directly connected to this section of the line.

3. Explanation of the write-up on "Valving Operations" is omitted, as this is a local problem.

4. **Remove Old Section of Line.**

a. Install bond cables and place tools and equipment in position during blowdown time. *Bond cables are installed to eliminate the chance of static electricity jumping across the cuts and re-igniting the gas as the section is being removed or when the new section is being installed. Placing tools and equipment will reduce down time.*

b. When the blowdown has been completed and the line is ready to cut, make the first cut at the highest end. *When the section of the line has been blown down, approaching zero pressure, the blowoff valves at the main-line valves are closed and remain closed during the entire job. From this point on, the blowdown is completed and the amount of leakage controlled for cutting and welding at the 4-in. valve and stack installed at the job location. Standard practice is to cut at the highest end first and work away from the stack on cutting and back to the stack on welding.*

c. Single cut with torch and seal behind the cutter with mud. *Fig. 4 shows the single cut being made and a man mudding the cut behind the cutting torch. Mud is used to cut down on the amount of fire the welder has to contend with, and also to conserve gas if the shutoff is near 100 per*

FIG. 13. Nightcaps being removed from the west end of the new section.

FIG. 14. Pipe being lined up. As soon as the joint is lined, gas will be bled into the line through the ½-in. by-pass line at upstream main-line valve. This will purge the exhaust gas from the new section of pipe.

FIG. 15. One of the 12-in. bands being seal welded.

FIG. 16. The completed welding job.

cent. The first cut is always a single cut in case the line is in tension and pulls apart when the cut is completed. This eliminates the necessity for a double cut. This picture also shows the bond cables installed and the outside line-up clamp ready to move into position to complete the cut. Note that the man operating the fire-control valve is bleeding gas into the line at the ¼-in. connection, as the fire is quite low.

d. Use the outside line-up clamp to complete cut. *See Fig. 6.*

e. After completing cut, put out fire, remove the clamp and wrap with wet canvas, and secure with banding tape. *See Fig. 7.*

f. Make second cut at the other end of the job. Double cut if necessary. *Same procedure as first cut. When a double cut is necessary to make clearance to remove the old section, the cuts are beveled towards each other. The outside line-up clamp is installed to complete the cuts on top of the line and to cut the small ring on each side, the fire extinguished, and the clamp removed. If there is any compression on the line, the beveled cuts force the cut ring out. If not, they are very easily removed because of the beveled cuts.*

g. Third cut at the center of the section. *Same procedure as first cut.*

h. Use the closest 4-in. fire control-valve to the cuts to control fire. *The closer the 4-in. valve is to the cut, the better the control. See Fig. 8.*

i. Lift out section and install nightcaps in the open ends. *See Fig. 9.*

5. **Install New Section of Pipe.**

a. Remove the nightcap from the pipe at the west end of the job and cover the end of the pipe with wet canvas. Band canvas in place. *See Fig. 10.*

b. Install bond cables to the new section. As the new section is being moved into place, remove the nightcaps from the old and new pipe at the east end. *See Fig. 11.*

c. Line up pipe, install, and tape band. *See Fig. 12.*

d. Install blocking under the new section. *As the preliminary work was being performed, elevation shots were made and stakes set on one side of the ditch where the crib blocking would be installed. When the old pipe was re-*

FIG. 17. Estimated job schedule. If the job is well planned, the time shown in the estimated schedule is a good average in which the job can be performed.

• ESTIMATED SCHEDULE •
EAST WHITTIER FLOOD CONTROL JOB

1ST HR.	REDUCE PRESSURE FROM 200# TO 125#	¾ HR.
2ND HR.	BLOWDOWN	1¼ HRS.
3RD HR.	CUT AND REMOVE OLD SECTION OF LINE	1½ HRS.
4TH HR.		
5TH HR.	INSTALL NEW SECTION OF PIPE, PURGE, SEAL WELD BANDS AND BULL PLUGS	1¾ HRS.
6TH HR.		
7TH HR.	COMPLETE WELDING 6 WELDERS	2¾ HRS.
8TH HR.		
9TH HR.	PACK AND PUT LINE IN SERVICE	1 HR.

FIG. 18. The actual schedule. By comparing one schedule with the other, we can determine the parts of the job in which improvements can be made.

• ACTUAL SCHEDULE •
EAST WHITTIER FLOOD CONTROL JOB

1ST HR.	REDUCE PRESSURE FROM 200# TO 125#	15 MIN.
2ND HR.	BLOWDOWN	1 HOUR 24 MIN.
3RD HR.	CUT AND REMOVE OLD SECTION OF LINE	2 HOURS 13 MIN.
4TH HR.		
5TH HR.	INSTALL NEW SECTION OF PIPE, PURGE, SEAL WELD BANDS AND BULL PLUGS	1 HOUR 46 MIN.
6TH HR.		
7TH HR.	COMPLETE WELDING 6 WELDERS	2 HOURS 24 MIN.
8TH HR.		
9TH HR.	PACK AND PUT LINE IN SERVICE	39 MIN.

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moved, crib blocking was installed to the grade of the stakes. When the new section was moved in place, it was at the proper elevation when it was set on the blocking.

e. Raise the pipe on the west end enough to remove the nightcap. *See Fig. 13.*

f. Line up joint and purge new section of pipe by bleeding gas into the line at upstream main-line valve (use 1½-in. by-pass line). *See Fig. 14.*

g. When the purge has been completed, remove the canvas covering the end of the pipe at the west end and install the 12-in. band. *When the purge has been completed, the canvas shown in Fig. 13 will be removed and the band installed as shown in Fig. 11.*

h. Check amount of gas for welding. Ignite gas from top of bell-hole. Control fire and seal weld. *See Fig. 15.*

i. As soon as the seal welding has been completed at the west band, remove the tape from the east band. Ignite gas from the top of the bellhole, control fire, and seal weld east in 12-in. band. *As soon as the seal welding was completed at the west band, the tape was removed from the east band and seal welded. We hold to the practice of never welding at more than one opening at a time until all seal welding has been completed.*

j. Stop welding at the bands while removing the 4-in. fire-control valves and installing the 4-in. bull plugs. *This is only a safety practice.*

k. Complete welding on the 12-in. bands and the 4-in. bull plugs.

l. Pack and put the line in service.

m. Remove the ½-in. by-pass line at upstream main-line valve.

n. Put the automatic controllers in service at Valves No. 25 and No. 24.

o. Turn on the rectifier nine miles upstream.

Job Schedules

The estimated schedule is simply a goal to try to meet. Quality of work is not sacrificed, however, to try to complete the job within the schedule.

On May 22, 1955, this same crew performed a similar job in 7 hours and 35 minutes. This is considered excellent time for any crew.

Regardless of the method used, thorough job planning is very important. We believe that the "Fire Control" method affords the best opportunity to incorporate safety in the planning.

The main rule to follow when using the "Fire Control" method is to keep the line filled with gas at all times. This is possible except when installing the new section and until it is purged. If this rule is followed, the line can be packed and put in service as soon as the welding has been completed.

Leak Repairs

On leakage repairs, installing the 4-in. fire-control valves or when grinding longitudinal seams, the following policy is observed:

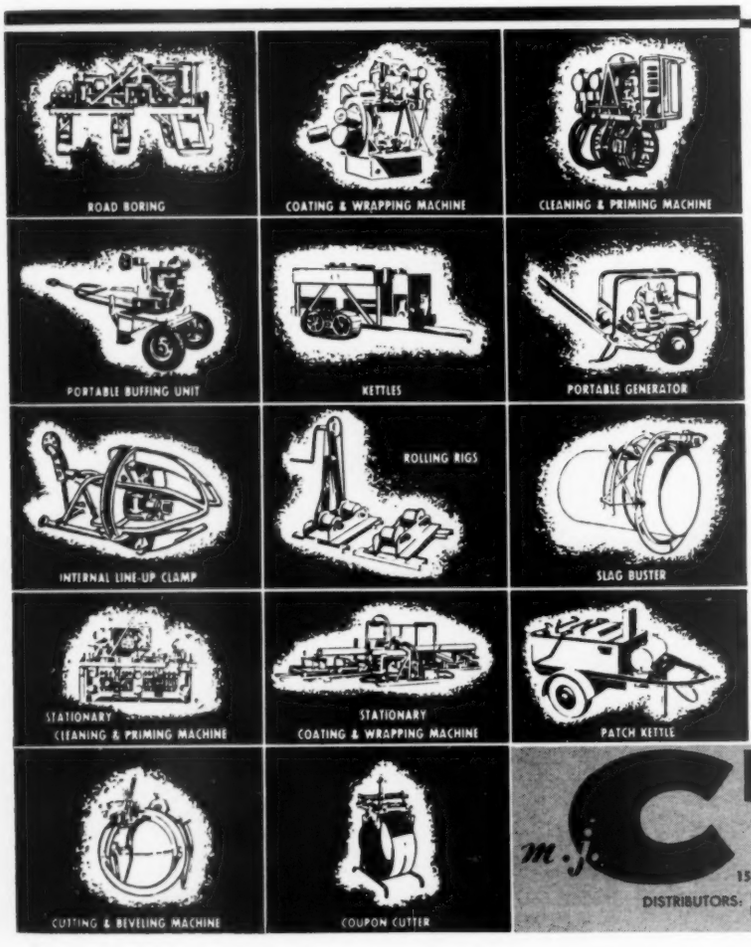
Welding and grinding is permitted if the line pressure is reduced or is operating at 50 per cent of the guaranteed minimum transverse-yield strength of the pipe.

If the line is operating above 50 per cent of the guaranteed minimum yield strength, we wait until the line is shut down and the pressure reduced by the blowdown before installing the "Fire Control" valve or grinding the long seams.

Acknowledgment

This discussion was originally presented at the 10th Annual Gas Technology Short Course, Texas A&I College, Kingsville, Texas, and sponsored by the Southern Gas Association, June, 1955.

* * *



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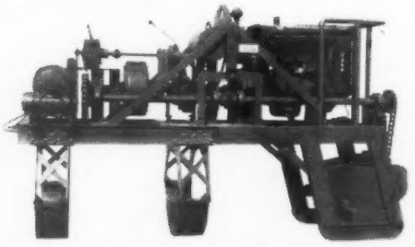

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— *Photos courtesy U. S. Army and Caterpillar Tractor Company*

Manifold transfer building of one of the Alaskan pipe line pump stations. Tank farm is in background.

Construction Report

P 616.053

Alaskan Products Line in Operation

A Petroleum Engineer Staff Report

EXCLUSIVE

Construction crewmen check pressures during hydrostatic test of line. Trailer mounted pressure pump is in background.

WITH TESTING OF THE LINE AND other facilities completed, operation of the 625-mile Alaska military products pipe line between Haines and Fairbanks is scheduled for full operation in early September.

Contractors for the $40,000,000 major construction project by the Army Corps of Engineers were Williams Brothers, Tulsa, Oklahoma; McLaughline Construction Company, Great Falls, Montana, and Marwell Construction Company, Vancouver, British Columbia.

The line, which will supply U. S. military forces at Alaskan bases with various types of petroleum products, will have a 209,000-bbl fill. Initial capacity of the system will be 12,000 bbl per day. An initial 50,000 bbl of diesel fuel has been received at Haines, where all products will arrive by tanker.

Operation for a 30-day period as preparation for acceptance of facilities by the Army was undertaken by Williams Brothers, following water testing. The line was tested to pressures of 1200 and 1900 psi.

Normal operation will be for a period of 12 days per month. Standby capacity is designed to accommodate increased demands or emergency conditions that may arise.

Rapid Construction

Total time for construction of line, 625.77 miles of 8-in., was 20 months. Clearing operations began in mid-December, 1953, and continued through the winter months despite temperatures at low as —60 F. Welding of the line

View of pump station layout, manifold, and tank farm lines at one of the five stations on the line.

Route of the 625-mile line follows the Alcan Highway from Haines to Fairbanks. It is visible from various spots along the famous roadway. Pipe was laid bare after studies by corrosion engineers indicated line could be safely operated without protection.

began April 19, 1954, and continued until October 15, 1954, completing the line construction—with the exception of a few tie-ins — in less than six months.

Construction of the five pump stations and terminal facilities began in April, 1954, and continued until mid-December when cold weather forced shutdown of all operations until late February, 1955, when work was resumed at the Haines and Tok Junction stations.

During the peak of the construction work in 1954, some 775 men were employed on all phases of the work. Some 280 were on the two pipe line spreads and the remainder were employed in constructing other facilities.

Pipe

Pipe used in construction of the line was 8⅝ OD with .277-in. and .312-in. wall thicknesses. The heavier wall pipe was used for stream crossings and a total of 19,711 ft of the .312-in. was used on the discharge side of station No. 2. Pipe used was a low carbon, seamless steel line pipe, 0.215 maximum carbon, with check analysis running principally 0.14 to 0.205 carbon.

Average Pipe Laid

The Alaskan pipe line spread averaged 70,330 ft, or 1675 joints of pipe per week, while the Canadian spread averaged 75,768 ft, or 1804 joints of pipe per week. The Canadian spread operated on a 7-day week while the Alaskan spread worked 6 days a week.

Most Pipe Laid

The Alaskan spread set the record of the project, completely welding 542 joints—or 27,764 ft of pipe. This constituted 4.31 miles of pipe line completed during the course of a 12-hour day.

The Canadian spread's best record for a 12-hour day was 420 joints of pipe, or 3.3 miles of pipe line.

Seasonal Factors

Typical of all construction in Alaska and other far northern areas, the construction season is principally limited to the period of May 1 plus or minus, through November 1, plus or minus. Work started on April 19, 1954, except for clearing, which was started in December, 1953, and was not shut down until December 15, 1954, due to an unusually late winter.

Hazards Encountered

There were no outstanding hazards connected with the project other than those generally attributed to pipelining. The weather was such that only reasonable precautions were needed for the protection of men and equipment while operations were under way.

While wildlife was plentiful along the route of the pipe line, this did not constitute a real problem. There were several cases of fright reported by men who encountered bears, but the experiences did not constitute dangerous incidents. Snakes are not to be found in Alaska or Northwestern Canada.

While quicksand areas were to be found along the line, they were generally small areas or frozen over when encountered.

Muskeg areas did constitute a hindrance for men and equipment, with equipment frequently becoming bogged down and occasionally dropping "out of sight" in flooded areas requiring dragline retrieving of the equipment and dunking of the operators.

Soils and Terrain

Type of soils encountered varied from solid rock at isolated locations through gravelly, sandy soils with little or no frost content to muskeg and tundra underlain by permafrost soils. In a good many instances, where encountered, the permafrost started immediately under the grass roots and continued to undetermined depths. When the cover or insulating blanket of vegetation was disturbed, the underlying permanently frozen soil began to thaw, and the right-of-way became a quagmire with equipment wallowing through mud down to the underlying ice.

Terrain can be generally classified as ruggedly rolling, of the type encountered along the foothills of very rugged mountain ranges. Beginning at the heavily timbered, mountainous country north of Haines, the pipe line ascends to its maximum elevation of 3750 ft in the Coastal Range at Mile 55. The pipe line then begins its gradual descent to the undulating interior valley of Northwestern Canada and Central Alaska. Heavy timber is encountered only in the vicinity of Haines, with timbered areas along the remainder of the line comprised chiefly of the scrub fir that is peculiar to Arctic regions. Muskeg

Workhorse of the construction gang and most outstanding equipment innovation was this ditcher. A reinforced 12-ft wheel with 14 buckets was substituted for standard 18-ft wheel. Teeth on buckets were replaced often, received hard wear "biting" the hard permafrost.

and tundra with underlying permafrost is generally encountered on the flats between the hills. Permafrost, however, was occasionally found on the tops of hills.

Construction Methods

A modified ditching machine, with backhoes and clamshells was used to dig the necessary ditches for required pipe line burial, road crossings, and stream crossings. No standard thaw program was used where permafrost was encountered. Blasting was resorted to where ditching was necessary in solid rock, and occasionally for permafrost.

Modification of the ditching machine was in the substitution of a reinforced 12-ft diameter wheel for the standard 18-ft wheel. Fourteen buckets were used on the special digging wheel, reducing the spacing between buckets.

This provided the machine with a continuous digging cycle eliminating "jarring" action and increasing the life of the ditcher despite the difficult material through which it excavated. Approximately 122 miles of pipe line burial was required due mainly to permafrost. At the height of the construction season, the ditching operation was conducted on a 24-hour a day basis, with two 12-hour shift crews, working six days per week. The operation closed down on Sundays to permit overhaul and repair of the ditching equipment.

The ditcher-backhoe-clamshell team operated with the ditcher excavating through icy and non-icy soils while the backhoe and clamshell cleaned the ditch behind it. The backhoe and clamshell were used for the ditching in those areas where boulders and rocky-type soil were encountered.

Unusual Clearing Methods

Two unusual techniques were introduced into clearing operations at Haines by the contractor. One involved the use of a steel clearing ball, 6 ft in diameter, pulled by two tractors. This method was effective only in small brush and completely ineffective in the heavy timber at Haines and was finally abandoned.

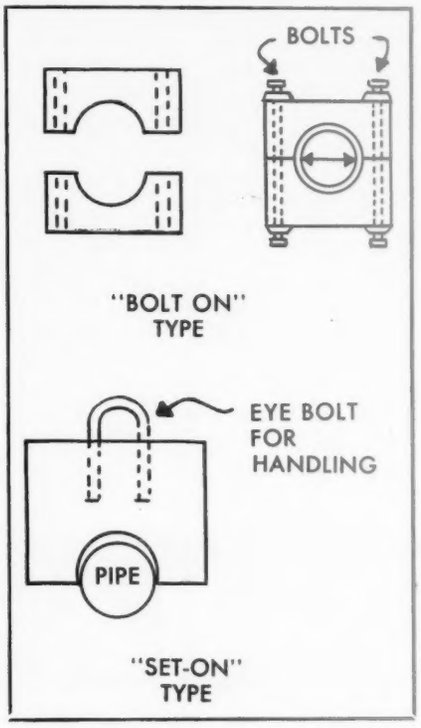
A second unusual method attempted at Haines was the use of a "spur tree" for collecting stumps and logs into burn-off piles. A dragline attached to the top of the spur tree by pulleys dragged the heavy stumps and logs into a pile at the base of the tree for burning. This method also proved ineffective in the heavy timber and was eventually abandoned.

Kluane Lake Construction

When the project was offered to contractors for bidding, estimates were requested on making a 7-mile lake crossing and on carrying the line around the lake. While skirting the lake added eight miles to the total length of the pipe line, this method proved the most economical. Had the lake crossing method been adopted, it would have been the deepest water crossing ever attempted in pipe line history. Kluane Lake is 290 ft deep.

Weather Difficulties

Flash floods in Kluane Lake region resulting from heavy rains and melting glaciers washed out portions of the right-of-way, highway, and bridges, causing delay in that part of the construction. Many rock wash areas required extensive burial for protection. Frequent swampy areas caused by melting permafrost delayed operations and necessitated detours.



Types of weights used. These were cast of concrete at station sites using plywood forms.

Equipment

Equipment failure was not a prominent factor in work delays. Due to the type of terrain encountered and weather conditions, however, maintenance costs were high.

Case of the "Oozy" Pipe

In the swampy areas caused by the melting permafrost, pipe burial became a problem. When the pipe was buried in the soil, the weather was warm and the ground "oozy." When the freeze came, the permafrost soil froze from the bottom up, pushing the pipe to the top, the buoyant line then riding on the surface.

Concrete weights were placed on line in swampy, permafrost country to keep pipe from being "oozed" out of ground as permafrost refroze.

This was overcome by using concrete weights of two types. Initially, bolt-on types cast in halves and fastened by bolts were used. A second type—a set-on type—was placed on the line for additional negative buoyancy. (See illustration).

No special plant was developed to cast the weights. They were cast out-of-doors at station sites where concrete mixing equipment was available, using plywood forms, and then hauled to locations where needed.

Housing for Men

Fixed camps consisting of dormitory-type bunkhouses (2 men to a room) were provided at all five pump stations. Each camp was completed with both hot and cold running water, showers, indoor plumbing, laundry facilities, and modern messhall. The size of the camps varied with the size of the station being constructed and the maximum number of men being employed on the job.

The two mainline pipe spreads (one pipelining through Alaska and the other in Canada) were housed in modern trailers. The two camps moved with the progress on the pipe line, setting up at 75-mile intervals along the route. Additional camp facilities were provided by trailer offices, kitchens, and messhalls. Each camp was complete with trailer-mounted bath house with showers, hot and cold running water, and laundry facilities.

Where work necessitated the use of smaller trailer camps, these were set up as side camps, and in some instances commercial lodge facilities along the Alaska Highway were utilized to provide lodging for smaller crews operating away from established camps.

Recreation for Workers

There was little time for recreation for the crews and few recreational facilities available. Workers, however, took advantage of opportunities for fishing and hunting in season, played baseball, played cards, attended dances when in the neighborhood of the small villages, and attended movies that were shown for the crews once or twice each week.

Terminal Facilities

Terminal facilities of the pipe line are located at Haines and Tok Junction, Alaska. These facilities include:

At Haines (Station No. 1). Petroleum Wharf. A T-type structure of steel "H" pile with concrete deck. The wharf face is 200 ft in length. Depth of water from M.L.L.W. is 40 ft. **Storage Tanks.** Nine 30,000-bbl, two 5000-bbl, and one 1000-bbl welded steel cone-roof storage tanks. Completing the facility are universal manifolding and transfer pump facilities to permit inter-transfer between all tankage.

At Tok Junction (Station No. 3). Facility includes nine 30,000-bbl, three 5000-bbl, and one 1000-bbl-welded steel cone-roof storage tanks; a universal manifolding and transfer pump facilities to permit inter-transfer between all tankage.

Pumping Station Facilities

Five pump stations were provided in the overall project. Of these, three will be used for normal pumping operations, the other two as needed to meet operating demands.

The stations, equipment, and capacities are:

Station No. 1. Located on the Lutak Inlet, three miles from Haines, Alaska. Elevation of mainline pump building is 35 ft. Twelve buildings make up the facility including the mainline pump building, a three-unit radiator building for mainline pump engines, manifold and transfer pump building, a utility building containing electrical generators and steam boilers, a four-unit radiator building for generator engines, office and garage, a composite garage, shop and warehouse, POL laboratory, two 8-family apartment buildings, a 10-man dormitory, and a cold storage locker building.

Pumping Equipment. Three quinti-

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plex reciprocating in parallel, each pump rated at 272 gpm maximum at 110 rpm with 4½-in. plungers, 1200 psi maximum discharge pressure. Pumps are driven by 6-cylinder diesel engines rated at 285-hp at 720 rpm. Speed reducers are used between the engines and pumps.

Electrical Power. Four kw generators, each rated at 150-kw, 480-v, .8 pf, 60-cycle, driven by 6-cylinder diesel engines.

Station No. 2. Located 48 miles northwest of Haines, on the Haines Cut-Off highway in British Columbia, Canada. Elevation of mainline pump building is 1300 ft. Nine buildings make up the facility including the mainline pump building, three unit radiator building for the mainline pump engines, utility building containing electrical generators, steam boilers, and water and fire pumps, a two-unit radiator building for generator engines, water tank building, composite garage, shop and warehouse building, one 6-family apartment building, a 10-man dormitory, and a cold storage locker building.

Pumping Equipment. Three 4 by 6, 4-stage centrifugal pumps in series driven by 285-hp, 6-cylinder diesel engines through speed increasers. Maximum station discharge pressure is 1450 psi.

Electrical Power. Two 150-kw generators of same specifications as those at Station No. 1.

Station No. 2-A. Located 10 miles northwest of Haines Junction on the Alaska Highway in the Yukon Territory, Canada. Elevation of mainline pump building is 2773 ft. Four buildings make up the facility including an emergency pump building, a two-unit radiator building for mainline pump engines, a bunkhouse and utility building containing quarters for five men, garage, water supply, and electrical generators, and a cottage for the resident operator.

Pumping Equipment. Two 4 by 6 4-stage centrifugal pumps in series driven by 8-cylinder diesel engines rated at 450-bhp at 840 rpm, through speed increasers.

Electrical Power. Two 50-kw generators rated at 55-kw, 480-v, .8 pf, 60-cycle driven by diesel engines.

Station No. 2-B. Located on the Alaska Highway, Mile Post 1124, nine miles southeast of the Donjek River in the Yukon Territory, Canada. Elevation of mainline pump building, 2673 ft. Four buildings make up the facility. A water well with pump house three miles from the station has also been added.

Pumping Equipment and Generators: Same as Station No. 2-A.

Station No. 3. Located seven miles west of Tok Junction on the Alaska Highway. Elevation of mainline pump building is 1591 ft. Eleven buildings make up the facility including the mainline pump building, three-unit radiator building, a utility building containing electrical generators, steam boilers, and water and fire pumps, three-unit generator building for generator engines, water tank building, manifold and transfer pump building, composite warehouse, shop and garage, one 8-family apartment, one 4-family apartment, a 10-man dormitory, and a cold storage locker building.

Pumping Equipment. Three quintiplex pumps, same specifications as at Station No. 1. Two triplex pumps rated at 44.7 gpm maximum at 90 rpm with 3-in. plungers, 1200-psi maximum discharge pressure driven by diesel engines through speed reducers. These triplex pumps are for pumping from Station No. 3 to Big Delta, Eielson AF Base, and Ladd AF Base, utilizing the existing 3-in. *Canol line*.

Electrical Power. Three 150-kw generators, same specifications as at Station No. 1.

Take-off facilities are provided at Big Delta, Eielson, and Ladd to meter and direct fuel to storage and to fuel handling equipment. No pumping equipment is provided at these take-offs.

* * *

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Come storms and/or high water, Texas Illinois Natural Gas Pipeline Company maintenance crews are ready with their . . .

Emergency Pipe Line Repair Equipment

Keith Bentz

EMERGENCY REPAIR EQUIPMENT HAS always been an important item to a pipe line company. Such equipment, supplementing normal maintenance equipment, has generally been adequate for repair work on pipe lines located in arid or well drained sections of the country.

The Texas Illinois pipe line traverses lowland areas in Missouri, Arkansas, and Texas. Numerous rivers, creeks, bayous, and swamps are found in this region. Annual rainfall is approximately 50 inches and periods of extensive flooding occur during the rainy season. After flood waters have subsided, the saturated lowlands have a heavy mud mantle, which causes conventional pipe line equipment to mire.

EXCLUSIVE

The cost of repairing the ravages of weather and taking preventive measures against the extremes of weather runs into millions of dollars annually for the pipe line industry. The obvious effect of weather on certain areas of the natural gas business requires that all operations be keyed for quick action if storms result in a pipe line failure.

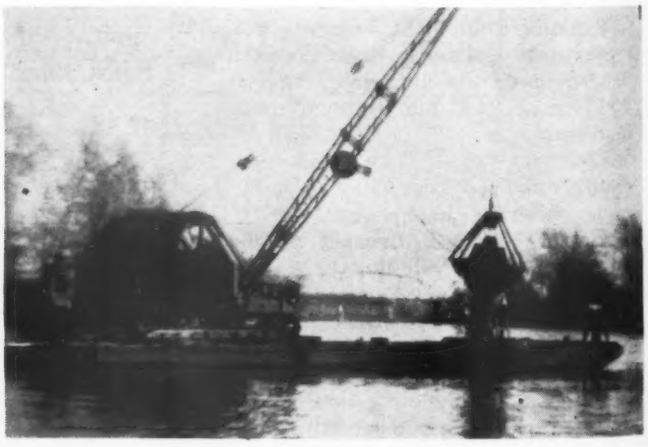
The special pipe line equipment procured by Texas Illinois is designed to make an emergency repair of possible pipe line failures under adverse conditions in the shortest possible time. Thus, the health, comfort, and well being of the 6,500,000 population comprising its market area will not be unduly jeopardized by a fuel shortage.

Special Equipment

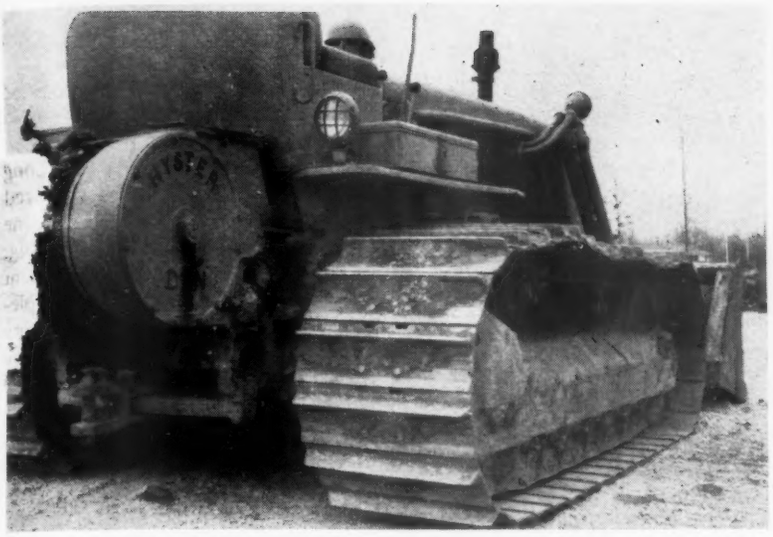
The conclusion of a thorough study of all available information resulted in a decision that certain specific equipment and material items would be needed to expedite emergency repairs of a pipe line failure occurring in a swamp or inundated flood plain. The following items of special equipment and materials have been procured or fabricated:

12½-in. O.D. by 0.500-in. Wall Line Pipe. 12½-in. OD pipe is stored at convenient compressor station locations nearby the areas subject to regular flooding. Approximately 11,500 ft is on hand for use as a temporary by-pass line in case of emergency. The 0.500-in. wall pipe provides net negative bouyancy, which will cause the by-pass line

Two individual barge units mounted on conventional pipe line truck for highway movement. Each single unit measures 8 ft by 20 ft by 2 ft 6 in. Five units pinned together provide a deck surface of 800 sq ft, which is ample room for men and equipment.



Shallow draft barge with crawler crane operating ½-yd clamshell bucket to excavate under water. Note mounted hand winch in upper corner of barge. The winch line is attached to a special grab anchor to anchor barge at a specified location.



View showing 24-in. wide tracks on crawler tractor. Conventional tracks for this unit are 16-in. wide. The 24-in. tracks permit operation in deep mud, which causes conventional equipment to mire.

Extension pads 26 in. wide bolted to conventional 16-in. wide tracks permitted this crawler crane to move under its own power. Scene is the flood plain of the Black River in northern Arkansas and is typical of most river bottoms after heavy rains. A conventional machine would have become mired in this condition.

to sink to the bottom of the water.

Skid-mounted, Single-Drum Pulling Unit. The single-drum pulling unit can accommodate more than 2000 ft of 1-in. wire line, and special cable-holding devices permit rearranging drum capacities as required.

A single-line pull is adequate for pulling several thousand feet of pipe and a double line will double the pulling capacity.

Wide-Track Crawler Tractors and Cranes. Wide-track equipment, called swamp-pad equipment in the industry, effectively improves floation of heavy crawler equipment. Crawler-type tow tractors and crawler cranes have been equipped with 24-in. wide and 26-in. wide tracks respectively.

This increase in track areas on the ground results in a unit ground pressure of about 6 lb psi. This is comparable to the ground pressure exerted by the average human foot.

Shallow Draft Barges. The shallow draft barges were designed and fabricated by company personnel. Since highway movement of equipment is necessary on a cross-country pipe line, the barge is made up of five individual units that can be hauled with conformation to highway laws.

Special devices permit pinning the individual units to form a barge capable of floating our heavy cranes over the water. Movement of the barge over the water can be accomplished with hand winches attached to special alloy marine grab anchors.

Placement and retrieving the grab anchors is accomplished by workmen in 16-ft aluminum work boats powered with conventional outboard motors.

Skid-mounted, single drum pulling unit operating during demonstration that moved a load in excess of planned procedures contemplated during an emergency. Special features of this unit are air clutches, direct drive, adequate special safety shield for operator.

Repair procedures under adverse conditions

Method	Conditions	Special Equipment To Be Used	Repair Procedure
1	Flood plain inundated with more than 4 ft of water.	Single drum pulling unit. 12½-in. OD by 0.500-in. wall pipe.	Well pipe in strings on one side of body of water. Pull across water with pulling unit. Tie-in to mainline on each side of water line.
2	Flood plain inundated with 1 ft to 4 ft of water.	Shallow draft barges floating excavating and repair equipment.	Excavate at point of failure. Construct cofferdam. Pump out excavation and repair.
3	Shallow water and/or heavy mud.	Wide-track tractors and cranes.	Road in equipment to point of failure, excavate and repair.

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This boat and motor is capable of moving the steel barge by an action similar to a tug boat.

Crash-type life jackets are provided for all employees on floating equipment as a safety precaution.

14-in. by 3/16-in. by 12-ft Long Interlocking Piling. Two hundred pieces of sheet piling are stored in the area subject to maximum flooding. This piling can be driven by equipment on the barge. The piling can supplement or replace earth for constructing a coffer dam at the ponit of the failure or at the point of connecting the 12-in. bypass line to the 30-in. mainline.

Most of the items listed are common to the pipe line construction industry. Portable barges capable of quick assembly at the job site, however, were another story. Barges are common to river and lake use where depth of water is always adequate. A pipe line failure may involve floating equipment in relatively shallow depths. The portable barges were designed and built for such conditions.

The Author

Keith Bentz is superintendent of pipe lines for Texas Illinois Natural Gas Pipeline Company. Bentz joined Natural Gas Pipeline Company of America, affiliate of Texas Illinois, in 1938 following his graduation from the University of Kansas. His first job was that of an engineer in the pipe line department, and later did inspecting on the river crossings. In 1942 he was made district superintendent for Texoma Production Company, and upon commencement of operations of Texas Illinois he became pipe line superintendent. In 1950 and 1951, he was field superintendent of pipe line construction.

Operating Experience

Normal operating experience on the Texas Illinois system to date confirms that this special equipment is well designed and constructed. The procurement of specialty items noted in the accompanying procedures chart in addition to normal operating equipment gives added assurance for a minimum of operating interruptions.

Mobile two-way radio communications provides important contacts during emergencies. With this equipment being readily available, we are enabled to expedite repairs in flood plains and swamps. Under more severe contingencies, this equipment will be a valuable supplement to heavy specialty contractor's marine equipment. * *

Pipe Line Projects

TGT-Trans Canada Contract Signed, 1050-Mile Pipe Line Planned

Tennessee Gas Transmission Company has signed a contract to buy 200,000,000 cu ft of natural gas per day from Trans Canada Pipe Lines, Ltd., at the international boundary near Emerson, Manitoba, with an option to buy an additional 200,000,000 cu ft per day when and if it is available.

To market the Canadian gas to American consumers, Tennessee Gas is proposing to construct a 1050-mile pipe line from the international boundary southeast through the states of Minnesota, Wisconsin, Illinois, Indiana, Kentucky, and Tennessee. It will connect near Nashville with the company's main, multiple pipe line natural gas transmission system, which now extends from South Texas northeast across or into 15 states to northern New England.

Canadian gas will be sold along the new Minnesota-Tennessee pipe line, principally to gas distribution companies having no present source of natural gas.

Application will be filed with the FPC in the near future for necessary permits to import the gas from Canada near Emerson, and to construct the proposed new line.

Tennessee Gas also has entered into a short-term contract with Trans Canada to sell up to 86,755,000 cu ft per day to Trans Canada at the international boundary near Niagara Falls. It will be transported through Trans Canada's existing pipe line from the boundary to Toronto, and on from that point through a Toronto-Montreal pipe line to be constructed by Trans Canada in the near future. The gas will be used to serve and develop markets in line to be constructed by Trans Contreal prior to completion of Trans-Canada's all-Canadian pipe line.

New TGT-Trans Canada line would include this 1050-mile gas pipe line.

When Trans Canada's line has been completed to eastern Canada, Tennessee Gas has agreed that at Trans Canada's request it will enter into a contract to purchase substantial quantities of gas from Trans Canada in eastern Canada. This gas would give Tennessee Gas a new supply source for its underground storage fields in Pennsylvania and New York and for its northeastern markets.

Cities Service to Build 238 Miles of Gas Line

Cities Service Gas Company has been given FPC approval to construct a total of approximately 238 miles of pipe line and a new 2700-hp compressor station on its transmission system in Kansas and Oklahoma.

The proposed construction, estimated to cost $8,422,000 includes 93 miles of 26-in. pipe line extending from Kay County, Oklahoma, to Montgomery County, Kansas; a new 2700-hp compressor station in Woods County, Oklahoma; and about 145 miles of gas gathering and transmission system in Woods County, Oklahoma, and Barber County, Kansas, connecting a new gas supply in Barber County with the proposed new compressor station.

Ohio Fuel Gas Plans 19 Miles of New Line

The Ohio Fuel Gas Company has received FPC authority to build 19 miles of gas transmission line and two new metering stations in western Ohio. The new facilities will increase the capacity of the company's system by approximately 14,300,000 cu ft per day. Total estimated cost of the project is $792,400.

The construction program includes 18.9 miles of 16-in. in Hardin and Allen counties, partially paralleling an existing line and connecting it with a proposed metering station at Lima. Ohio Fuel also will build a metering station near a new petrochemical plant of Standard Oil Company of Ohio at Lima.

Contracts . . .

Great Lakes Pipe Line Company has awarded contract for construction of a 106-mile, 12-in. products line to the **M-R Company of Wichita,** Kansas. The new line will parallel the company's existing 6 and 8-in. lines.

Interstate Oil Pipe Line Company has let contract to **Sam Carline, Inc., of Berwick, Louisiana,** for construction of approximately 13 miles of 16-in. crude line in Lafourche and Jefferson parishes of Louisiana. Most of the line is across marsh, with about 3 miles crossing Little Lake.

Southern Pacific Pipe Lines, Inc., has awarded contracts for the construction of three pumping stations on its new 846-mile products line. The Colton, California, station will be built by **J. H. Pomeroy and Company, Inc., of San Francisco;** the El Paso, Texas, station will be built by **Robert M. McKee, Inc., of El Paso,** and the Watson pumping station, near Wilmington, California, will be built by **J. A. McNeil Construction Company, of Alhambra, California.**

Firm also has let contract for 42 miles of 16-in. line between Colton and LaHabra, California, to **J. E. Young Pipeline Contractors, Inc., Los Angeles.**

Tennessee Gas Transmission Company has awarded contracts for construction of its new 370-mile, 30-in. coastal line between Kinder, Louisiana, and Agua Dulce, Texas. Contracts awarded include:

Morrison Constructors, Inc., Austin, Texas—93 miles, Agua Dulce to Lavaca Bay.

Williams Brothers, Tulsa, Oklahoma—73 miles, Lavaca Bay to Brazos River.

Houston Contracting Company, Houston, Texas—Brazos River to near Beaumont, Texas.

Western Constructors, Austin, Texas—Beaumont to Kinder, Louisiana.

N. A. Saigh Company, San Antonio, Texas—crossing of Guadalupe River.

Williams Brothers, Tulsa, Oklahoma—crossing of Colorado River.

Houston Contracting Company, Houston—crossing of Brazos River.

Panama-Williams Company, Houston, Texas—crossing of Houston Ship Channel and Cedar Bayou.

Associated Pipe Line Constructors, Inc., Houston, Texas—crossings of Trinity, Neches, and Sabine Rivers.

Larrabee Named Chairman NACE Technical Committee

C. P. Larrabee, Applied Research Laboratory, United States Steel Corporation, Monroeville, Pennsylvania, has been named chairman of the technical practices committee of the National Association of Corrosion Engineers. E. P. Greco, senior research chemist, research department, United Gas Corporation, Shreveport, Louisiana, has been named vice chairman.

Larrabee succeeds H. W. Schmidt, The Dow Chemical Company, Midland, Michigan, who has been chairman for the last two years. The technical practices committee is composed of the chairmen of the six major subdivisions of the association's technical committees plus the chairman and vice chairman and W. F. Fair, Jr., The Koppers Company, Pittsburgh, vice president of NACE.

The technical practices committee's function is to act on policy matters and generally supervise the technical committee activities of the association.

PLCA Meeting to Be Held in Florida

The eighth annual convention of the Pipe Line Contractors Association will be held in Boca Raton, Florida, January 16-18, 1956. Some 600 persons are expected to attend the convention, according to PLCA officials. Hotel reservations will be handled through a housing committee. Further information on the convention can be obtained from PLCA executive secretary Richard A. Gump, 2232 Republic National Bank Building, Dallas, Texas.

Board in Spain to Design Pump Stations

A three-man Navy-oil industry board of review is now in Spain to study the engineering and design of pump station facilities along the new U. S. military pipe line that will be built to supply American air bases there.

Members of the board are: Karl T. Feldman, director of engineering, Sinclair Pipe Line Company; D. W. Calvert, technical department, Phillips Pipe Line Company, and Earle Corliss, Bureau of Yards and Docks, U. S. Navy.

The purpose of the board's study is to insure that the best of current oil industry engineering practices are utilized in the design of the military line's pumping facilities.

The pipe line itself will run approximately 485 miles from Cadiz Bay to Zarogoza, passing close to the Spanish capital at Madrid. It will transport petroleum fuels from the seaboard to U. S. Air Bases.

Rapid Amortization Granted Two Pipe Line Projects

Transcontinental Gas Pipe Line Corporation, Houston, Texas, has been given ODM authorization to write off for tax purposes approximately 25 per cent of $79,497,703 worth of gas pipe line facilities over a five-year period. The fast write off is one of the largest recently granted.

Okan Pipe Line Company, Tulsa, Oklahoma, a subsidiary of Warren Petroleum was granted 25 and 40 per cent write off on $7,703,663 in facilities on a new pipe line system.

Okan Completes Line For Natural Gasoline

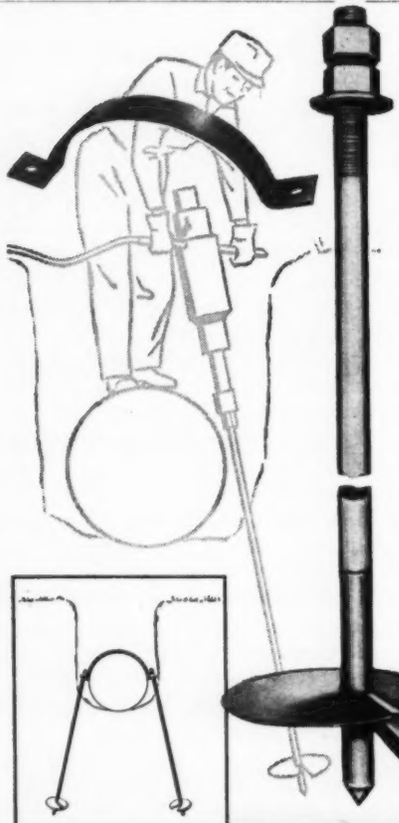
Construction of the first natural gasoline products pipe line from the southwestern Kansas Hugoton gas field to the Tulsa refining area has been completed by Okan Pipeline Company.

Okan is an affiliate of Warren Petroleum Corporation. The 353-mile pipe line system will operate as a common carrier for transportation of natural gasoline products.

Designed for an initial capacity of 10,000 bbl (420,000 gal) per day, the line ultimately can transport 20,000 bbl (840,000 gal) per day when additional stations are constructed. Completed August 1, line filling will require about 25 days. Connected plants have storage for five days' production and Okan has erected two 20,000-bbl pressure storage tanks at Okan's Liberal station, Seward County, Kansas. These tanks will be utilized as working storage for product segregation and batch accumulation. Products transported from the plants will be measured into the system through positive displacement meters.

One outdoor-type station, consisting of an 800-hp gas engine driving a 9-stage centrifugal pump through a 3.94 to 1 speed increaser, will meet initial pipe line pumping requirements. A duplicate unit will be installed as standby and to share the increased load at maximum line capacity during the winter months. The line is designed to operate with local automatic control at the stations and will utilize the latest developments of telemetering and remote supervisory control techniques.

The Okan organization, under the direction of Ernest A. Slade, president, consists of Charles W. Miller, vice president and general superintendent, Gil V. Rohleder, chief engineer, all directors of the corporation; D. M. Mattocks, secretary, A. J. Murphy, treasurer, A. B. Scurlock, civil engineer, G. D. Griffee, assistant engineer, T. M. Moore, material supervisor, L. A. Jackson and A. J. Wisdom, right-of-way.



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Contract Awarded for Spanish Pipe Line

A $4,956,000 low-bid joint venture contract for construction of a 475-mile petroleum, oil and lubricant pipe line to serve U. S. air bases under construction in Spain has been awarded to Merritt-Chapman and Scott Corporation, of New York; Benson and Montin, of Oklahoma City, Oklahoma, and Agroman Empresa Construction, of Madrid.

The pipe line, which will extend from the Atlantic Ocean seaport at Rota, near Cadiz, northwest to Zaragoza, will carry fuel from the seaport to six bases—Rota, San Pablo, Moron, Torrejon, Valenzuela, and San Jurjo. The route will pass in the vicinity of Seville, Cordoba, and Madrid.

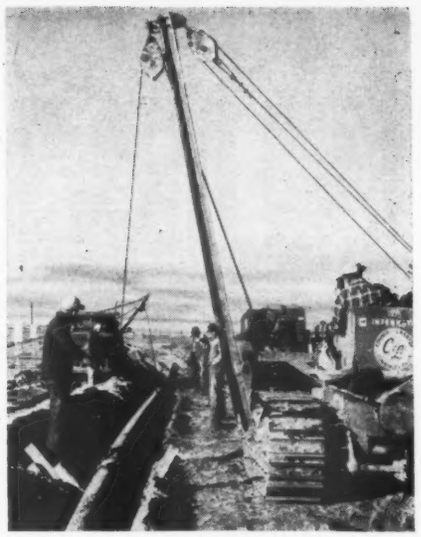
The 38,000 tons of 8, 10, and 12-in. diam. pipe are being provided by a British concern, Steward and Lloyd.

Prime contractors for the Spanish air bases project are Brown-Raymond-Walsh, a joint-venture group composed of Brown and Root, Inc., of Houston, Texas; Raymond Concrete Pile Company, of New York, and Walsh Construction Company of Davenport, Iowa.

Contracts Awarded for Two Canadian Lines

Two major contracts for natural gas pipe line construction in Saskatchewan for the current year have been awarded by Saskatchewan Power Corporation. Majestic Contractors, Ltd., Edmonton, has the 226 miles of 10, 12, and 14-in. line comprising a loop of 115 miles between the Brock-Coleville fields and Saskatoon by way of Biggar and a new stretch of 111 miles between Saskatoon and Prince Albert.

The other contract, for the Prince Albert city distribution system, has been awarded to Banister Construction, Ltd. of Edmonton and Saskatoon. This job consists of 53 miles of distribution mains from 2 in. to 12 in. and 179,000 ft of ¾-in. service lines.



WEST TEXAS casinghead gas, from new producing wells near Midland and Odessa will be utilized by this pipe line, recently completed for Texas Gulf Producing Company, to supply its new Headlee natural gasoline plant. Connor and Lasater Construction Company was contractor on the job.

NACE South Central Region Meeting Oct. 18-21

Ten symposia and at least 19 meetings of technical committees are scheduled to be held during the 1955 South Central Region meeting of the National Association of Corrosion Engineers. The meeting will be held at the Houston Hilton-Shamrock Hotel, October 18-21.

Gulf Building Pipe Line Terminal at Knoxville

Gulf Oil Corporation is building a pipe line terminal at Henson Road and Middlebrook Pike in Knoxville, Tennessee. The new terminal will take product from the Plantation Pipe Line, and is being built to better serve an increasing market in a 40-county area in Tennessee, Kentucky, and Virginia.

The terminal will receive gasolines and distillates from the pipe line.

Gas Imports Given FPC Approval

Montana Power Company, Butte, Montana, has been authorized by FPC to import up to 100,000,000 cu ft of natural gas per day, with a maximum of twenty billion cu ft per year, from Canada. The authorization runs until May 14, 1974.

Gas will be imported from the Pakowki Lake area in southeastern Alberta, produced by the Canadian-Montana Gas Company, Ltd., subsidiary of Montana Power. It will be transported by Canadian-Montana Pipe Line Company, another subsidiary.

Imperial Oil Plans British Columbia Products Line

Construction is underway on two major projects by Imperial Oil, Ltd., on the lower mainland of British Columbia. The two projects include a terminal in suburban Burnaby, and a 6-in. products pipe line about six miles long that will cross Burrard Inlet to link the new terminal with the IOCO refinery.

Estimated cost of the projects is near $1,000,000. Marine Pipeline and Dredging Company, Ltd., Vancouver, has been awarded the contract for construction of the pipe line. It will be the first products pipe line in western Canada, and is scheduled for operation in early autumn.

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Meetings . . .

Several important conferences have been scheduled for September and October that are of special interest to the pipe line engineering and operating people. Included are:

Products Pipe Line Control and Dispatching Group will have its seventh annual two-day meeting at the Lennox Hotel in St. Louis, Missouri, on September 22-23. Shell Oil Company is acting as official host. The group is composed of supervisors of products movement in those pipe line companies or departments engaged in movement of finished products through pipe lines. E. H. Baird, Wyco Pipe Line, Denver, Colorado, is chairman for the current year; R. E. Grimes, Phillips Pipe Line, Bartlesville, Oklahoma, is vice chairman, and W. J. Curry, Shell products pipe line department, New York City, is secretary.

Petroleum Branch, American Society of Mechanical Engineers, will hold its annual meeting in New Orleans, Louisiana, September 25-28, at the Roosevelt Hotel.

American Gas Association and Pacific Coast Gas Association will hold a joint national meeting in Los Angeles, California, October 17-19.

Electrical Conference of the Petroleum Industry (AIEE) will hold its second annual meeting in Houston, Texas, September 12-15, at the Shamrock Hotel.

The Petroleum Electric Power Association's 27th annual meeting will be held September 26-28 in Dallas with sessions at the Adolphus Hotel.

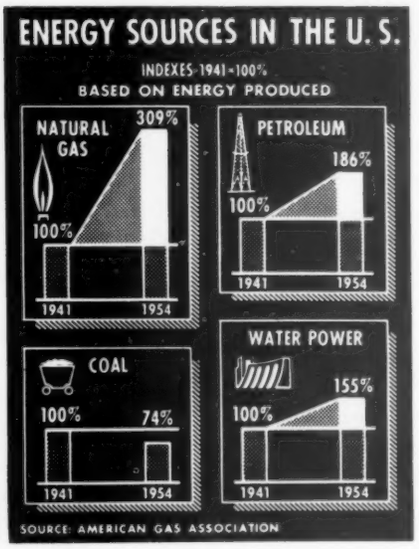
Program of the meeting will include a number of guest speakers and papers on topics of interest concerning electric power utilization by the oil and gas industry.

U. S. gas companies will be hosts to nearly 200 foreign visitors attending the 6th annual conference of the **International Gas Union.** The sessions, slated September 25-30 at the Hotel New Yorker in New York City, will bring representatives from 17 foreign countries. This is the first time the conference has met in the United States.

Plains Pipe Line Sold To Denver Group

Sale of the 80-mile Plains Pipe Line system in Wyoming has been made by the Clint Murchison interests of Dallas to a group of Denver, Colorado, purchasers. The buyers were Garfield and Pasternack, Denver producers, and A. K. Swan, Denver attorney.

The Plains system runs from Clareton field near Newcastle to Lance Creek. It has a daily capacity of 30,000 bbl.



Pure Buys Interest in Sinclair's "Big Inch"

Pure Transportation Company, pipe line subsidiary of Pure Oil Company, has acquired a minor interest in the Big Inch pipe line system of Sinclair Pipe Line Company. Pure Transportation bought an "undivided interest" in the 670-mile, 22 and 24-in. line that carries crude from Cushing, Oklahoma, to the Chicago area, where both Sinclair Refining and Pure Oil have major refineries. The undivided interest means Pure is acquiring a share in the physical assets rather than a stock interest.

Sinclair Pipe Line will continue to operate the line, which was completed in 1953.

Kansas Products Pipe Line System Planned

Standard Oil of Indiana's products pipe line department will soon place into operation a products system to serve Wichita, Kansas, and surrounding territory. The system includes 108 miles of converted 10-in. crude line, formerly owned by Service Pipe Line, and 6 miles of new 8-in. line. The line runs from Humboldt, Kansas, to a terminal at Valley Center near Wichita.

Wilcox Trend System Expansion Approved

Wilcox Trend Gathering System, Inc., subsidary of Texas Eastern Transmission Corporation, has received FPC approval on plans to expand its system capacity to approximately 200,000,000 cu ft per day. Facilities to cost approximately $2,900,000 will be built.

The new facilities include a 2000-hp compressor station in Goliad County near Charco, Texas; 2200-hp to be added at an existing station near Thomaston, Texas; 16 miles of 16-in. loop near Provident City, Texas additional smaller diameter lines, and one 75-hp field compressor station. The company will also purchase two existing lateral lines connecting wells to the main line.

Salt Lake Pipe Line Plans Loop Program

Salt Lake Pipe Line Company, a subsidiary of Standard Oil Company of California, has announced tentative plans to build 82 miles of 10-in. loop line along its existing 182-mile, 10-in. crude line between Rangely, Colorado, and Salt Lake City, Utah.

The new facilities would increase daily capacity from 46,000 to 55,000 bbl. The loop is also needed to improve winter operation, when low temperatures reduce the daily throughput.

Herscher Storage Field Expansion Approved

Natural Gas Storage Company of Illinois has embarked on a $7,500,000 expansion program at its underground gas storage facilities at Herscher, Illinois, following FPC approval of plans.

The program, which will result in an increase in peak day delivery capacity from 150,000,000 to 430,000,000 cu ft, will include construction of 31 miles of 36-in. pipe line and installation of a permanent gathering system to recover and return venting gas to the reservoir.

The new 36-in. line will run from the Herscher field to a point on the Texas-Illinois Natural Gas Pipeline Company system where it crosses the Illinois River south of Joliet.

Horsepower Shift, New Facilities Given Okay

Texas Eastern Transmission Corporation and Texas Eastern Penn-Jersey Transmission Corporation have received authorization from the FPC on a joint application to shift 10,000-hp presently installed or authorized for construction by Texas Eastern to the Penn-Jersey system and to construct additional horsepower on the Texas Eastern System and build two small loop lines in the Philadelphia area. Cost of the projects is $2,587,400 for Texas Eastern and $2,836,000 for Penn-Jersey.

The project includes an arrangement to shift horsepower presently installed or authorized for construction at Texas Eastern's Phoenixville, Chambersburg, and Wind Ridge, Pennsylvania, stations to the Penn-Jersey system, the construction of 3300 additional reciprocating horsepower at Texas Eastern's Linden, New Jersey, station, and the construction of approximately eleven miles of pipe line loops in the Philadelphia area. New Penn-Jersey facilities will include a 5000-hp gas turbine centrifugal station at Perulack, Juniata County, Pennsylvania, and a 5000-hp gas turbine centrifugal station at Grantville, Dauphin County, Pennsylvania.

WITH THE

PIPE LINE CONTRACTORS

● **B&M Construction Corporation, Oklahoma City, Oklahoma.** Has contract for construction of 475 miles of 8, 10, and 12-in. products line from Rota to Zaragoza, Spain, for *U. S. Navy* as part of joint venture with Merritt-Chapman & Scott Corp., New York, and Agroman Empresa Construction, Madrid. A. C. Montin, project manager, in care of Hilton Hotel, Madrid, Spain. Job started June 1, 1955. Also has 90 miles of 22-in. between Sage, Wyoming, and Lava Hot Springs, Idaho for *Pacific Northwest Pipe Line.*

● **Pipe Line Service Company, Seminole, Oklahoma.** Has 140 miles of 24-in. for *Transok Pipe Line Company* between Lindsay and Tulsa, Oklahoma.

● **Merritt-Chapman & Scott Corporation, 260 Madison Avenue, New York 16, New York.** Has 53 miles of 8 to 24-in. between Bombay and Butcher Island for *Bombay Port Trust, India.* Also joint venture with Benson and Montin and Agroman Empresa Construction for 475 miles of 8, 10, and 12-in. between Rota and Zaragoza, Spain, for *U. S. Navy.*

● **Panama-Williams Company, Melrose Building, Houston, Texas.** Has crossings of the Houston Ship Channel and Cedar Bayou for *Tennessee Gas Transmission Company* on its new 370-mile Agua Dulce-Kinder 30-in. line.

● **J. E. Young Construction Company, Los Angeles.** Has 42 miles of 16-in. between Colton and LaHabra, California, for *Southern Pacific Pipelines, Inc.*

● **Hood Construction Company, Lynwood, California.** Has 112 miles of 8-in. and 35 miles of 12-in. for *Southern Pacific Pipe Lines* between Tucson and Hassayampa, Arizona.

● **Macco Corporation, Paramount, California.** Has 128 miles of 12-in for *Southern Pacific Pipe Lines* between Hassayampa, and Yuma, Arizona.

● **Pipe Line Contracting and Drilling Company, P. O. Box 165, Lemoyne, Pennsylvania.** Has 46 miles of 26-in. in three loops in West Virginia and Maryland for *Atlantic Seaboard Gas Corporation.*

● **Western Constructors, Austin, Texas.** Has 81 miles of 30-in., between Beaumont, Texas, and Kinder, Louisiana, for *Tennessee Gas Transmission Company.*

● **N. A. Saigh Company, San Antonio, Texas.** Has crossing of Guadalupe River for *Tennessee Gas Transmission Company,* on its new 370-mile, 30-in. Aqua Dulce-Kinder line.

● **Associated Pipe Line Contractors, Box 13216, Houston, Texas.** Has 71 miles of 30-in. in Virginia and Maryland for *Transcontinental Gas Pipe Line Corpora-*Jensen, Utah and Green River, Wyoming, for *Pacific Northwest Pipe Line.* Also has *tion.* Also has 77 miles of 26-in. between 227 miles of 16-in. for *Butte Pipe Line* between Guernsey, Wyoming, and the Montana line. Also 425 miles of 4, 6, and 8-in. products pipe line for Turkey, sponsored by NATO. Also has river crossings of the Trinity, Neches, and Sabine Rivers for *Tennessee Gas Transmission Company* on its new 370-mile, 30-in. Agua Dulce-Kinder line.

● **Williams Brothers, National Bank of Tulsa Building, Tulsa Oklahoma.** Has 160 miles of 6-in. for *Bolivian government,* oil line. Has 115 miles of 30-in. between Toledo and Cleveland, Ohio, for *East Ohio Gas Company.* Has 72 miles of 30-in. in Virginia for *Transcontinental Gas Pipe Line Corporation.* Has 120 miles of 30-in., sections II and III, between Gillis, Louisiana, and the Mississippi River, for *Texas Eastern Transmission Corporation.* Also has 73 miles of 30-in. for *Tennessee Gas Transmission Company,* Lavaca Bay to Brazos River, including crossing of the Colorado River.

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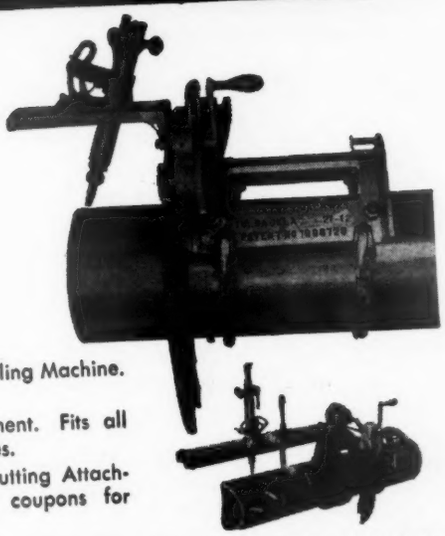

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Contractors

● **Dutton-Williams Brothers, Ltd., Pacific Building, Calgary, Alberta.** Has 51 miles of 4 and 6-in. from Joffre and Clive fields to Stettler, Alberta, for *Canadian Gulf Pipe Line Company*.

● **J. H. Pomeroy and Company, Inc., Los Angeles.** Has contract for pump station at Colton, California for *Southern Pacific Pipelines, Inc.*

● **R. H. McKee, Inc., El Paso, Texas.** Has contract for El Paso pump station for *Southern Pacific Pipelines, Inc.*

● **J. A. McNeil Construction Company, Alhambra, California.** Has contract for Watson pump station for near Wilmington, California for *Southern Pacific Pipelines, Inc.*

● **Fulton-Banister, 409 Northern Hardware Building, Edmonton, Alberta.** Has 65 miles of 12-in. and 41 miles of 16-in. for *Peace River Oil Pipe Line Company, Ltd.*

● **Sheehan Pipe Line Construction Company, 514 NBT Building, Tulsa, Oklahoma.** Has 6600 ft of 16-in. river crossing on Red River, near Ringling, Oklahoma, for *Sinclair Pipe Line Company*. Also has 49 miles of 8-in., Chester to Allentown, Pennsylvania, for *Keystone Pipe Line Company*. Also has 17,000 ft of 16-in. at Toledo, Ohio for *Wolverine Pipe Line Company*. Also has 75 miles of 8-in. reconditioning between Lima, Ohio and Huntington, Indiana for *Buckeye Pipe Line Company*.

● **Modern Welding Company, Inc., Box 528, Owensboro, Kentucky.** Has 12 miles of 2 to 4-in. for *Southeast Alabama Gas District*. Has 55 miles of ¾ to 6-in. for *City of Flora, Illinois*. Has 65 miles of 1 to 6-in. for *City of Covington, Georgia*. Has 32 miles of ¾ to 4-in. for *Sylvania, Georgia*. Has 60 miles in Winchester, Virginia, ¾ to 10-in., for *Shenandoah Gas Company*.

● **Dunn Brothers, Inc., Mercantile Securities Building, Dallas, Texas.** Has following hauling and stringing jobs: 76 miles, 26-in., in Tennessee and Kentucky, and 115 miles of 8, 10, and 12-in. in Kentucky and Indiana, all for *Texas Gas Transmission Corporation*, H. C. Price Company, prime contractor; 74 miles of 24-in., in New York, New Jersey and Pennsylvania, for *Tennessee Gas Transmission*, Bechtel Corporation, prime contractor; 134 miles of 30-in. in Louisiana and Mississippi for *Texas Eastern Transmission Corporation*, H. C. Price, prime contractor; undetermined mileage, various sizes, San Juan Basin area, for *El Paso Natural Gas Company;* undetermined mileage, 30-in., Indiana and Kentucky, for *American Louisiana Pipe Line Company*, H. C. Price, prime contractor.

● **Morrison Constructors, Inc., Austin, Texas.** Has 93 miles of 30-in. between Agua Dulce and Lavaca Bay, Texas, for *Tennessee Gas Transmission Company*.

● **Anderson Brothers Corporation, Box 8157, Houston, Texas.** Has 88 miles of 10 and 12-in. from Poplar to Glendive, Montana, for *Butte Pipe Line Company*.

● **Hallmac Construction Company, 2261 West Holcombe, Houston, Texas.** Has approximately 100 miles of 10-in. for *South Georgia Natural Gas Company*.

● **Cumberland Contracting Company, Monticello, Kentucky.** Has approximately 225 miles of 2 through 10-in. for *Southeast Alabama Gas District*

● **River Construction Company, 6100 Camp Bowie Boulevard, Forth Worth, Texas.** Has 150 miles of 8-in. between El Paso, Texas, and Lordsburg, New Mexico, for *Southern Pacific Pipe Lines, Inc.* Also has 150 miles of 26-in. between Ignacio, Colorado, and Moab, Utah, in two spreads, for *Pacific Northwest Pipe Line Corporation*.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has 140 miles of 22-in. for *Colorado Interstate Gas Company* from Laramie, Wyoming, to Denver, Colorado. Also has 59 miles of 30-in. for *Texas Eastern Transmission* between De Quincy, Louisiana, and Beaumont, Texas. Also has (with H. C. Price Company) 783 miles of 30-in. for *American-Louisiana Pipe Line* from Willow Run, Michigan, to Eudora, Arkansas. Some 400 miles to be built in 1955, 215 by Houston and 185 by Price. Also has 96 miles of 30-in. from near Beaumont, Texas, to the Brazos River, for *Tennessee Gas Transmission Company*.

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has for *Tennessee Gas Transmission Company* approximately 18 miles of 24-in. connecting Harrison and Hebron Storage fields and 50 miles of mainline, 24-in. Also has 77 miles of 26-in. in western Kentucky and Tennessee in six main line loops, plus 77 miles of 16-in. in Kentucky and Indiana, 5 miles of 8-in. and 35 miles of 10-in. in Indiana for *Texas Gas Transmission Corporation*. Also has 134 miles of 30-in. for *Texas Eastern Transmission* between Mississippi River near New Roads, Louisana, and Clinton, Mississippi. Also has (with Houston Contracting Company) 783 miles of 30-in. between Detroit and Louisiana-Arkansas line for *American-Louisiana Pipe Line*, of which 400 miles will be built in 1955, 185 by Price and 215 by Houston.

● **Bechtel Corporation, 220 Bush Street, San Francisco, California.** Has 121 miles of 12-in. between Minot and Williston, North Dakota, for *Montana-Dakota Utilities Corporation*. Also has 35 miles of 16-in. for *Michigan Gas Storage Company* in Michigan.

● **Pentzien, Inc., 1504 Dodge Street, Omaha 2, Nebraska.** Has the following crossings under construction: For *Texas Eastern Transmission Corporation*, two 30-in. crossings on the Neches River, two 30-in. and one 16-in. on the Atchafalaya River; for *Texas Gas Transmission Corporation*, one 26-in. crossing of the Cumberland River near Gilbertsville, Kentucky, and two 12-in. lines across Ohio River near Derby, Indiana; for *Tennessee Gas Transmission Company*, two 30-in. crossings on Ohio River near Portsmouth, Ohio, one 26-in. crossing on Mahoning River near New Castle, Pennsylvania, and one 24-in. crossing on Delaware River near Milford, Pennsylvania.

● **H. B. Zachry Company, Box 2570, San Antonio, Texas.** Has 67 miles of 30-in. for *Texas Eastern Transmission* between Clinton and Kosciusko, Mississippi. Also has 214 miles of 22-in. between Burley Idaho and Payette, Idaho for *Pacific Northwest Pipe Line*.

● **Engineering-Construction Company, 402 North Cheyenne, Tulsa, Oklahoma.** Has 150 miles, 6 to 10-in. gas line for *Southeast Alabama Gas District*. Two spreads: Gene Coulter, superintendent at Eufaula, Alabama, and Jim Williams, superintendent, Headland, Alabama.

● **Engineers Limited Pipe Line Company, 225 Bush Street, San Francisco, California.** Has 226 miles of 16-in. for *Butte Pipeline Company* from Fort Laramie, Wyoming, to Hammond, Montana.

● **Mid States Construction Company, Box 417, Mt. Vernon, Illinois.** Has 110 miles of 2 through 12-in. for *South Georgia Natural Gas Company*.

● **A. J. Curtis Construction Company, Box 2009, Casper, Wyoming.** Has 83 miles of 22-in. between Green River and Sage, Wyoming, for *Pacific Northwest Pipe Line Company*. Also has 54 miles of 16-in. lateral and 31 miles of 2 through 18-in. near Kemmerer, Wyoming, for *Pacific Northwest Pipe Line*.

● **R. H. Fulton & Company, Box 1526, Lubbock, Texas.** Has 150 miles of 8-in. between Tucson, Arizona, and Lordsburg, New Mexico, for *Southern Pacific Pipe Lines*. Has 160 miles of 26-in. for *Pacific Northwest Pipe Line* between Moab and Jensen, Utah. Has 256 miles of 22-in. between Rock Springs and Laramie, Wyoming, for *Colorado Interstate Gas Company*. Also has 43 miles of 10-in. and 16 miles of 3 to 10-in. near Rangely, Colorado for *Pacific Northwest Pipe Line*.

● **Fulghum Contracting Company, Harrisburg, Pennsylvania.** Has 198 miles of 22-in. between Payette, Idaho, and the Columbia River at the Oregon-Washington Border for *Pacific Northwest Pipe Line*.

● **Williams-Austin Company, 3322 Grant Building, Pittsburgh, Pennsylvania.** Has 35 miles of 26-in., three loops in Upshur, Braxton, and Randolph counties, West Virginia, for *Atlantic Seaboard Corporation*. Ed Peters general superintendent, L. A. Franks assistant superintendent, Ralph Gaddy spread superintendent.

● **C. P. Bartley and Son, Box 36, Tioga, North Dakota.** Has 20 miles of 2-in. through 8-in. gathering system for *Signal Oil and Gas Company*.

● **Baughman Contracting Company, Inc., R. D. 1, Box 569, Cumberland, Maryland.** Laying an undetermined amount of 24-in. through 16-in. gas lines in Maryland, Ohio, Pennsylvania, and West Virginia for *Cumberland and Allegheny Gas Company, Natural Gas Company of West Virginia*, and *Manufacturers Light and Heat Company*.

● **Conyes Construction Company, San Pablo, California.** Has 197 miles of 12-in. for *Southern Pacific Pipe Lines* between Yuma, Arizona, and Colton, California.

● **Williams Pressure Service Company, 422 Commercial National Bank Building, Shreveport, Louisiana.** Has test on 200 miles of 8 through 26-in. for *Texas Gas Transmission* on looping program. Also has 84 miles of 36-in. line to test for Houston Contracting Company on *Transcontinental Gas Pipe Line* looping program. Also has 385 miles of 30-in. to test for *Texas Eastern Transmission* on line between Beaumont and Kosciusko, Mississippi.

● **H. L. Gentry Construction Company, Box 32, Perrysburg, Ohio.** Has 16 miles of 8, 12, and 16-in. gas lines for *Iroquois Gas Corporation* at Colden, New York.

● **Buchanan Pipe Line Construction Company, Birmingham, Alabama.** Has 80 miles of 6 and 8-in. for *South Georgia Natural Gas Company*.

● **O. R. Burden Construction Corporation, 6702 East 21st, Tulsa, Oklahoma.** Has 103 miles 12 and 16-in. for *Butte Pipe Line Company* between Hammond and Cabin Creek, Montana.

● **Midwestern Constructors, Inc., 402 North Boulder, Tulsa, Oklahoma.** Has 95 miles of 22-in. between Lava Hot Springs, Idaho, and Burley, Idaho, for *Pacific Northwest Pipe Line Company*.

● **Missouri Valley Dredging, 22 William Street, Omaha 8, Nebraska.** Has approximately 6400 ft ditch and backfill on Hudson River Crossing near Dobbs Ferry, New York for *Tennessee Gas Transmission*. Also has two 30-in. crossings, Sabine River near Deweyville, Texas, and Bayou Courtableau, Port Barre, Louisiana, for *Texas Eastern Transmission*.

● **Somerville Construction Company, Ada. Michigan.** Has 22 miles of 16-in. for *Michigan Consolidated Gas Company*, from Sparta to Muskegon.

● **Hupp, Ltd., 332 West Seventh Avenue, Calgary, Alberta.** Has 400 miles of 4, 6, and 8-in. lines for *Pembina Pipe Line, Ltd.*, gathering system in the Pembina field of Alberta.

● **Majestic Contractors, Ltd., 408 Royal Trust Building, Edmonton, Alberta.** Has 226 miles of 10, 12, and 14-in., for *Saskatchewan Power Corporation* in Saskatoon and Saskatchewan.

● **Banister Construction, Ltd., 409 Northern Hardware Building, Edmonton, Alberta.** Has 53 miles of 12-in. distribution system for the city of Prince Albert, Canada.

● **M-R Company, Wichita, Kansas.** Has 106 miles of 12-in. between Des Moines and Iowa City, Iowa, for *Great Lakes Pipe Line Company*. Also has 6 miles of 8-in. near Humboldt, Kansas, for *Standard Oil Company of Indiana, Products Pipe Line Department*.

● **Sam Carline, Inc., Box 138, Berwick, Louisiana.** Has 13 miles of 16-in. in Lafourche Parish, Louisiana, for *Interstate Oil Pipe Line Company*. Also has undetermined amount of 3 and 4-in. for *Shell Oil Company* in East Bay, Louisiana.

Service Pipe Line Adding Four New Booster Stations

Three new 1250-hp pump stations are in the final stages of completion on the Service Pipe Line system between Casper and Ft. Laramie, Wyoming, a fourth is underway near Lost Cabin, Wyoming, northwest of Casper.

The four new stations will give service a needed capacity boost into the firm's 625-mile line between Ft. Laramie and Freeman, Missouri. Construction of the stations is part of a capacity expansion program that includes the laying of a 10-in., 13½ mile line between Salt Creek and Casper, replacing an older 6-in. line.

Each of the stations will be of outdoor-type design, unattended, and operated by remote control from the next major pump station upstream.

Crude, Products Line Revenue Up in First Half

Transportation revenues for the first six months of 1955 of the 66 pipe line companies reporting to the Interstate Commerce Commission were up 8.1 per cent over the corresponding period in 1954. This year's total was $304,-118,269, compared to $281,363,151 for last year.

During the same period, the number of barrels originated and received from connections also showed a gain of 5 per cent, increasing from 1,802,366,-000 bbl in 1954 to 1,954,965,000 bbl in 1955.

New Products System In Operation

Texaco-Cities Service Pipe Line Company's first products system, a 106-mile, 6 and 8-in. line between Tulsa and Ponca City, Oklahoma, has been placed into operation. It will carry products from the West Tulsa Texaco refinery to a connection with the Cherokee Pipe Line Company system at Ponca City, for shipment to terminals at Oklahoma City and Wichita, Kansas.

The new system was developed from an existing 60-mile, 6-in. crude line between Ponca City and Cushing bought from another pipe line company and converted from crude service, and a new 46-mile, 8-in. line from Tulsa to Cushing built by Texaco-Cities Service.

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PIPE LINE PERSONALS

▸ **M. A. Levy** has been appointed superintendent products movements of the Southern Pacific Pipe Lines, Inc. Levy will headquarter in Los Angeles, California. **B. K. Smith** has been named as new assistant general manager for the company.

▸ Acting Secretary of the Interior **Clarence A. Davis** announced today that the membership on the Military Petroleum Advisory Board has been increased from 24 to 27 members to obtain the experience and advice of the gas industry on matters relating to national security and defense under consideration by the board.

The new members are **Grove Lawrence,** vice president, Southern California Gas Company, Los Angeles, Calif., **A. W. Lundstrum,** president, The Ohio Fuel Gas Company, Columbus, Ohio, and **John F. Merriam,** president, Northern Natural Gas Company, Omaha, Nebraska.

At the board meeting on June 28, the Military Petroleum Advisory Board Chairman **W. W. Keeler** named the chairman and members of the newly established Gas Transmission and Distribution Panel of the board.

A. W. Lundstrum, president, The Ohio Fuel Gas Company, Columbus, Ohio, was named chairman of the Gas Transmission and Distribution Panel. Other members of the panel are: **John H. Carson,** vice president, The East Ohio Gas Company, Cleveland, Ohio; **Stewart P. Coleman,** vice president and director, Standard Oil Company (New Jersey) New York, New York; **Grove Lawrence,** vice president, Southern California Gas Company, Los Angeles, California; **John F. Merriam,** president, Northern Natural Gas Company, Omaha, Nebraska; **Richard E. Nelson, Jr.,** general manager, crude oil supply and products pipe lines, Standard Oil Company (Indiana), Chicago, Illinois; **Charles E. Webber,** assistant manager, natural gas department, Sun Oil Company, Philadelphia, Pennsylvania.

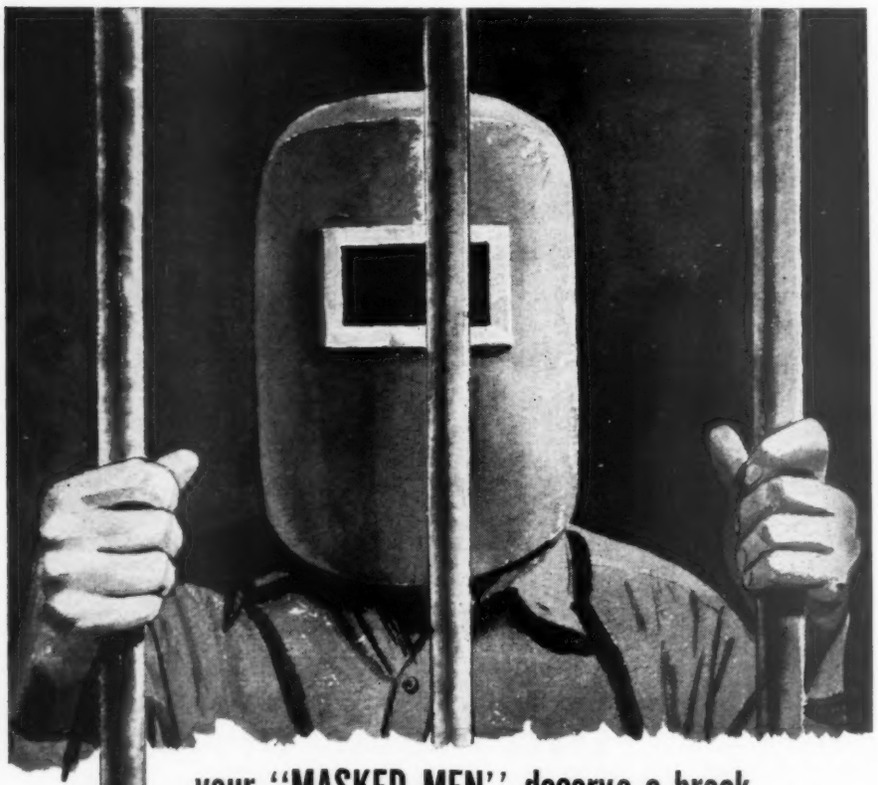
▸ Elevation of two Pacific Gas and Electric Company executives to the rank of vice president has been announced. **Sherman L. Sibley,** an engineer and assistant to the president, was appointed vice president and assistant general manager of the company. **Robert R. Gros,** manager of advertising and publicity, was appointed vice president, with responsibility for informational activities and special assignments by the president. Both Gros and Sibley are 41. Their appointments became effective August 1.

▸ **F. G. White** has been promoted to division superintendent of Magnolia Pipe Line Company's Northern division with headquarters at Oklahoma City. He succeeds **O. M. Joy,** who has retired. **A. J. Collins** has been transferred from Henderson station to Francis station as chief engineer, replacing **A. W. Noland,** who has retired. **G. W. Petrie,** mechanical engineer in Magnolia Pipe Line Company's general offices in Dallas, has been transferred to the South Saskatchewan Pipe Line Company as main line chief engineer with headquarters at Swift Current, Saskatchewan, Canada.

▸ **Louis E. Floyd,** manager of the Haughton, Louisiana, compressor station of Texas Gas Transmission Corporation since October, 1952, has been appointed manager of the company's new 4500 hp Columbia, Louisiana, station now under construction. Succeeding him at the Haughton station will be **Joe Russell,** former assistant manager at the company's Sharon station.

John W. Polkinghorn, director of the land and lease department of Texas Gas Transmission has retired. He has been in charge of obtaining pipe line rights-of-way and property for other facilities throughout the nine-state pipe line system for the past 26 years. He studied geology and mining engineering at the University of Kansas before joining Kentucky Natural. In October, 1949, following the merger of Kentucky Natural Gas Corporation and Memphis Natural Gas Company to form Texas Gas, Polkinghorn was appointed director of the new company's land and lease department.

▸ Appointment of **Homer R. Ross** as rate engineer of Southern Counties Gas Co. has been announced. Ross until recently was director of the fuel, power, and water division in the California Manufacturers' Association San Francisco office. He had held that position for the past four years. Ross' new duties will include cost of service studies, rate design, and assistance in the management of the gas company's rate department.



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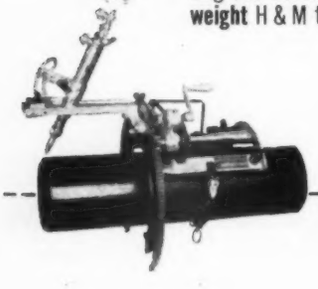

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Sometimes Elusive — Often Beneficial

oil and gas liens depend on statutes

Separate legislation is needed for the petroleum industry but the action to modernize security measures moves slowly

John C. Griffin

FINANCIAL risks in the extension of credit are accentuated for suppliers of materials and services to the petroleum industry because of the intrinsic character of the business of their customers. For this reason the matter of security is all important.

Of all forms of security, an oil and gas lien is one of the most beneficial and, at the same time, most elusive. On some occasions it springs to the rescue of the credit man, and on others it merely deludes him.

The reason for this apparent inconsistency lies in the fact that this type of lien is created by statute and depends for its effectiveness on the wording of the statute and the interpretation of that wording by the courts. A statutory lien cannot be molded to fit the particular needs of a transaction, as in the case with a pledge, mortgage, or other form of contractual security. Rather, it must be applied after the completion of the transaction. Often, when it is too late, the supplier learns that the type of transaction in which he has engaged is not covered by the law.

English common law, which our forefathers brought to America, recognized few liens, and these were mainly agrarian in nature. The industrial movement, however, required greatly expanded credit, which was possible only in an atmosphere of safety. Passage of lien statutes was the answer. They proved of benefit to all interests. The purchaser obtained needed credit; the supplier obtained needed security; and the states benefited by expansion of their industry, bringing additional revenue.

Initially, the statutory lien took its most common form in a general mechanics' lien law. Many such laws were passed before the discovery of oil and gas in commercial quantities, and hence transactions involving oil and gas wells were not covered. Later, however, a few states added new sections to their general mechanics' lien laws in an effort to encourage the new industry. Some merely inserted the words "oil and gas wells" in the list of improvements that could be subjected to lien. Others, acknowledging the special characteristics of the oil and gas industry, added sections to the law dealing exclusively with suppliers to that industry.

Even this latter approach had drawbacks, however, because some of the problems confronting oil and gas suppliers could not be easily fitted into the scheme of a general mechanics' lien law. As a result, a few of the more progressive states, realizing the importance of credit in the development of their natural resources, enacted separate and distinct oil and gas lien statutes.

The Author

John C. Griffin, of Pittsburgh, Pennsylvania, was graduated from the University of Michigan Law School in 1939. Right after graduation he joined The National Supply Company and has been with them since, except when he served in the U.S. Army from 1942 to 1946 in the European theater. He has been chairman of the Lien Law Committee, PESA, since its inception.

Need for Separate Legislation

Perhaps a few illustrations will make clear the need for separate legislation:

1. Under accepted theories of a general mechanics' lien act, a lien may be filed for the sale price of material covered by a single contract only. This may be satisfactory for the building trades, but it does not fit in with practices in the petroleum industry. A supply house rarely enters into a contract to supply all of the material necessary for a given well or series of wells; rather, it sells individual items of material as and when needed and ordered by a customer, on a running account basis. Obviously, it would be undesirable to compel the supply house to file an individual lien for each item of material supplied; and yet that is what is required under most general mechanics' lien laws, for each delivery is regarded as an individual contract.

2. Credit terms are longer in our industry than in many others covered by general mechanics' lien laws, thus requiring a longer period in which to file liens. Because the oil and gas industry is one of frequent ups and downs, it is also desirable that the lien foreclosure period be longer so that a customer may work out of his difficulties without the expense and confusion of a law suit.

3. We cannot ignore the fact that we are dealing with a "wasting asset" industry. The most valuable portion of a producing lease is the production itself, which is lost to the lienor unless provision is made to impound the runs in his favor.

Oklahoma Passed First Statute

Oklahoma enacted the first complete oil and gas lien statute in 1905 and Kansas followed suit in 1909. Texas and Wyoming joined the fold in 1917 and 1919 respectively. Arkansas passed its law in 1923 and Louisiana in 1928. Three states, New Mexico, Michigan, and Illinois, joined the parade in the

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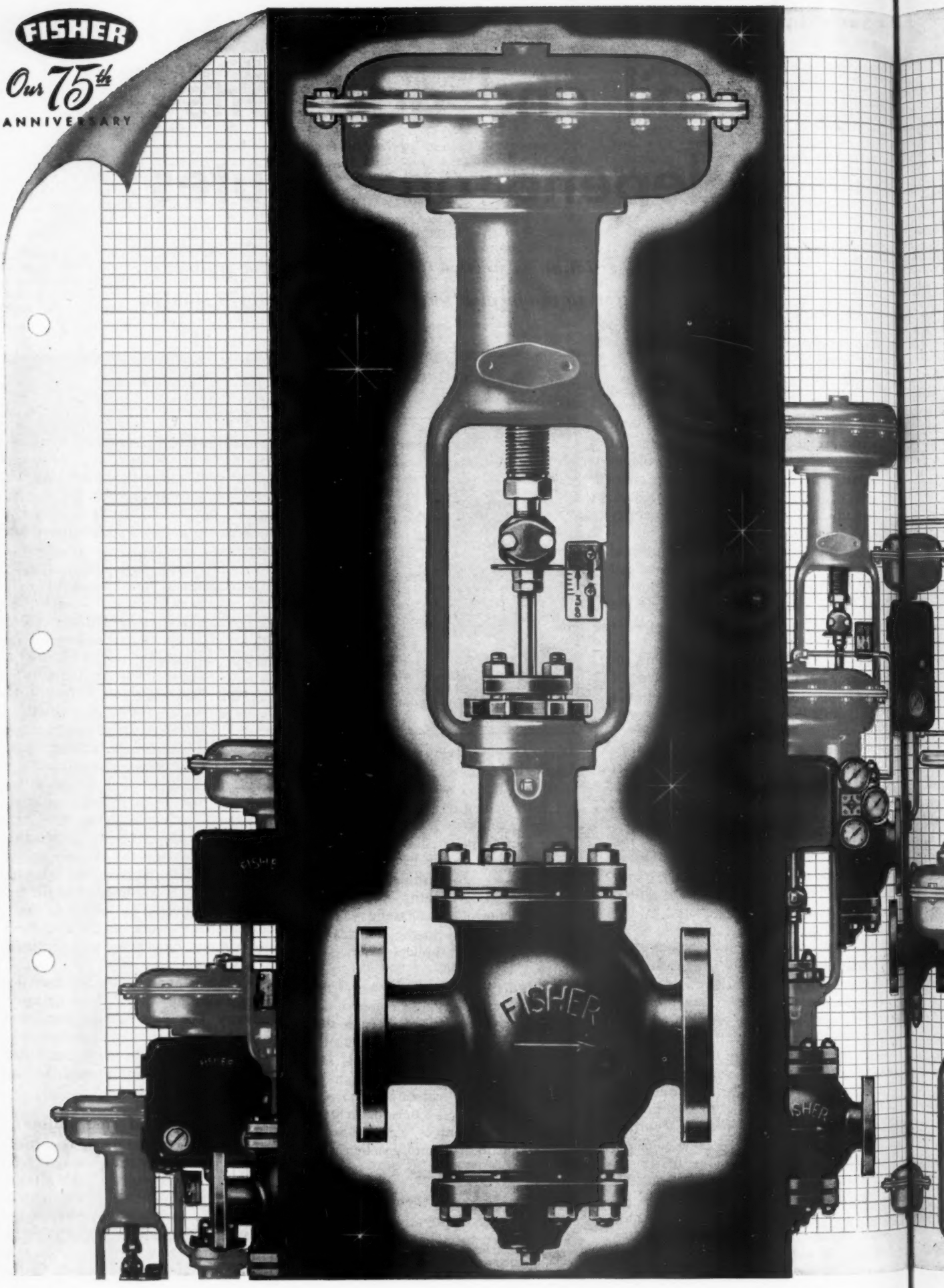

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1930s. The statutes vary in their language, but it is generally agreed that the results obtained are similar under each.

The Illinois statute, adopted in 1939, marked the first significant departure from the trend of its predecessors. Clearly and concisely written, it contains statutory definitions, thus eliminating possible misinterpretations by the courts. It recognizes the value to the lienor of the oil, both in place and produced, and provides for a lien on such oil. But despite its good features, this statute would doubtless contain some changes if it were to be enacted today.

By November, 1951, oil and gas had been discovered in new states, creating a need for lien legislation; and court decisions had been rendered in the earlier oil states that nullified some of the protection which should be afforded by their lien statutes. Consequently, at that time, the Petroleum Equipment Suppliers Association appointed a committee to study and take action on the problem of modernizing the existing statutes and promoting the adoption of statutes in those states that had none.

Basic Requirements Established

As its first step, the committee established in layman's language, the basic requirements of an adequate statute, devoting more than six months of study to this in an attempt to compromise the various conflicting interests. The committee recognized, for example, that labor liens should have a certain amount of preference, because a man working for wages can ill afford to take a loss. It recommended that all other liens be on a parity, even though this resulted in some loss of position to a supply company as opposed to a service company.

Further, the committee adopted a theory that oil and gas should be subject to lien as and when produced, but that purchasers of such oil and gas should receive adequate notice of liens so that they would not be placed in jeopardy. It carefully avoided any requirement that would have the effect of slowing down the free flow of money from the owner to the contractor and, in turn, to the subcontractor. It promoted a two-year foreclosure period, rather than a shorter one, so that a hard-pressed owner might have longer time to work out his difficulties. It recognized the need for adequate protection to the lease owner in the farm-out situation.

After establishing the basic aims, the committee began the task of writing a model lien statute. This took another six months, during which four separate drafts were written before the final form of the proposed statute was agreed upon.

The committee has neither sponsored nor supported legislation without prior consultation and discussion with other interested groups, particularly those representing the interests of lease owners. For example, before taking its first such step, in Texas during 1953, the committee consulted the Mid-Continent Oil and Gas Association on its proposal to introduce the model statute. Because of the lack of time, the model statute was not pushed, and, instead, amendments to the existing law were successfully introduced and supported.

Texas Amendments

Enacted in 1917, as one of the earliest in existence, the Texas statute did not meet modern conditions, and the amendments were therefore of far-reaching importance. Briefly, they:

1. Eliminated the necessity for filing copies of written contracts, thus making the filing job easier.

2. Lengthened the filing period from four months to six months.

3. Adopted the running account theory, making it unnecessary to file a statement of lien within a certain number of months *after each delivery*.

Prior to amendment, the Texas courts had interpreted the statute as requiring the statement of lien to be filed within four months after the last delivery under the contract, and went on to hold that each delivery constituted an individual contract in most instances. For all practical purposes, this severely limited protection under the lien law; suppliers simply could not file a lien for each delivery if they were to maintain good relationships with their customers.

The amendment of 1953 declared that *all* deliveries to a given lease should be considered as a single contract as long as not more than six months intervened between deliveries. This meant that a supplier could hold off the filing of a lien until after the last delivery to the lease, affording obvious benefits both to him and to the lease owner.

Successes and Failures

In 1954 the committee undertook the project of supporting the adoption of the model statute in Mississippi. That state had no oil and gas lien statute, and its general mechanics' lien law afforded no protection. The committee spent several days in conference with members of other associations and had their support at the date of introduction of the bill. Unfortunately, the effort failed, because members of the legislature honestly but mistakenly misinterpreted the aims of the committee. Another attempt will be made in 1956, and it is hoped the results will be favorable.

In 1955 the committee supported the adoption of the model statute in North Dakota and of certain amendments in Wyoming. North Dakota was the first state to enact the statute in its entirety, a step which it is hoped other states will follow. The Wyoming amendments, although too numerous to treat in detail, gave recognition to the "wasting asset" nature of the industry and extended the lien to cover oil and gas as and when produced; they also materially simplified the filing procedure.

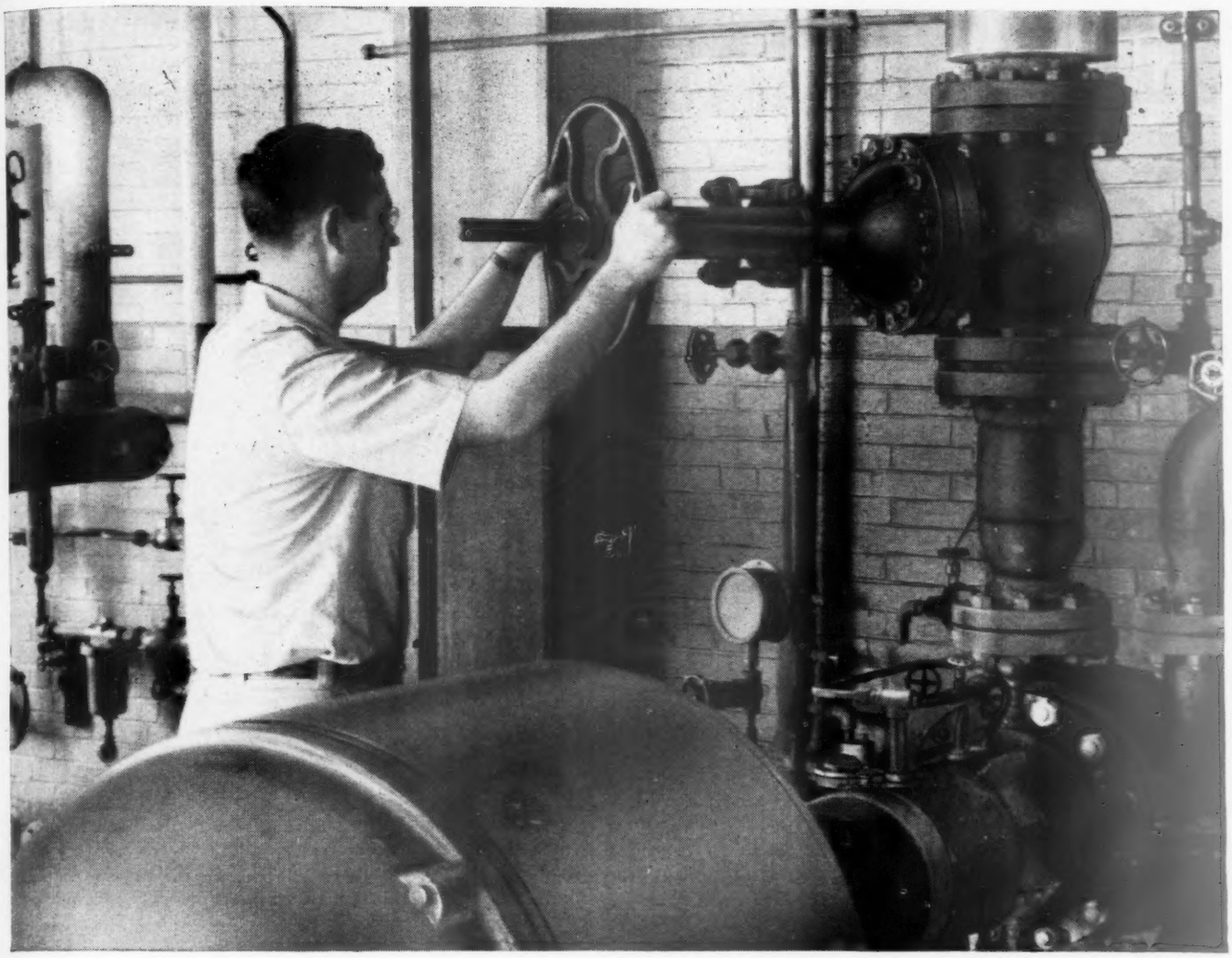
During the same year, however, efforts to obtain passage of the model statute in Nebraska ended in failure. The statute had the support of the Nebraska Bar Association and the Rocky Mountain Oil and Gas Association and certain major producers; but at the time a full-fledged conservation bill and several other lien acts were also in controversy before the legislature, and none were passed.

Active Support Needed

Little can be stated about future activities of the committee, because plans have not been specifically formulated. It is the aim of the Petroleum Equipment Suppliers Association and the committee to continue the project to completion, and it is hoped that it will merit the support of various other groups associated with the industry. A bill, good or bad, rarely becomes law without active support; legislators need to know that their favorable vote on a bill is desired by their constituents.

For the particular benefit of persons who deal in credit extension, a word of caution may not be amiss. Passage of the best possible lien statute is not a cure-all. It will not make a producer out of a dry hole, nor will it reinstate the value of used, depreciated equipment. By the same token, the task of following and proving deliveries to particular leases will still be present. An oil and gas lien statute is not a vehicle to justify credit extension in a particular account, but rather is a means of justifying a credit policy generally, and possibly of salvaging an account that otherwise might be lost. Such a statute cannot help but promote the expansion of the industry of a state, help lease owners and their contractors obtain credit, and protect contractors, truckers, service companies, supply houses, and laborers; but it is not a panacea.

Readers who have suggestions concerning the subject matter of this article are invited to submit them to the writer, and are assured that they will be appreciated and studied. * * *



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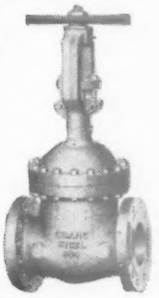

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SUPERVISION . . .

Key to Effective Communication†

Millard E. Stone*

Radio, television, letters, telegrams, pamphlets, manuals, all substitute for face-to-face communications —Supervisors can generate more personal understanding and add to effectiveness of written word

JUST a year ago, in the great city of New York, there was a dramatic instance of complete failure of communication. A man had been arrested, charged with felonious assault. Consistent with due process of law, he was arraigned promptly before a city magistrate. Now in New York, as well as in all other states, an accused is entitled by Constitution to be informed of the charge against him.

There was a difficulty in this case: The accused could neither hear nor speak. So the legal machinery encountered its first obstacle. Quickly a court clerk wrote out the charge, and held it before the prisoner's eyes. His reaction was an unconcerned shrug, and a shake of his head. You guessed it! He couldn't read.

An expert in sign language was summoned . . . still no results. The accused again shrugged and shook his head. Here was the ultimate in "failure of communication"—in a most vital situation. No "lines of communication" could be found. Unless the prisoner could be made to know the nature of the charge against him, there could be no valid prosecution. And there seemed to be no way to reach his understanding.

The helpless magistrate conferred with the prosecutor and with the defense attorney, who had been assigned by the court. They got nowhere. Meanwhile tension had begun to grow in the crowded courtroom; voices rose in conversation; there was uneasy, nervous laughter. Finally the case was adjourned, to give the judge and lawyers time to figure out a solution. For the time being, let us leave them there, in search of their solution, while we examine the fundamentals of their problem.

As we left them, they had failed to find the *key* to communication. We don't need to overexercise our imagination to figure out a way in which they might have reached his understanding quickly. Certainly *someone* had been getting through to him in the normal course of his life—someone up to then must have been making him understand. Some person *who had lived with him* day by day would be the logical one to serve as the means of communication between him and the authorities. The solution, then: Find that someone, get that someone to understand, and thus transmit the message to him.

Employees *Want* to Understand

In one vital respect, there is a wide difference between the problems of company communication and the story I have just recounted. In the courtroom scene, we cannot be certain that our man was capable of understanding or, in fact, that he *wanted* to understand. By sharp contrast, we know that, in industrial communications, the audience not only is capable of complete understanding, it wants almost anxiously to be informed so that it *can* understand. The problem does not arise through any deficiency in the audience, whom we of industry try to reach. Where we are not being heard and understood, it is usually because we are not using the truly effective methods of transmission. Too often we fail to recognize the management "someone" who lives with the employee day by day and offers the most effective means to get through to his understanding. Obviously, that is the supervisor.

For the supervisor is the one person best situated to get management's message across to his subordinates. It is he who literally lives with his people in their working lives. It is the supervisor who has the continuous task of making matters clear to the employees as they go about the day's work. It is the supervisor who is in the best position to evaluate worker attitudes, to know how management messages will get maximum employee response. In short, the supervisor best understands the people in the rank and file. Also he is in the best position to understand management and the messages it is seeking to get through to the employees.

Notice that I have been speaking in terms of the supervisor's *potential* usefulness in industrial communication, by virture of his vantage point in any company. Too often management overlooks him when it seeks to communicate—or else fails to make maximum use of his role as a communicator. (His importance is accentuated, if we just think for a moment of the damage that the wrong kind of supervisor can do to the most expert management communications. I need not dwell on the point, I'm sure.) Like the "someone" in the courtroom stalemate, the supervisor is—or can be made to be —the most effective medium for transmitting the content of management's mind to the understanding of his subordinates . . . and, in reverse, for relaying employee reactions and attitudes back to management's own understanding.

Communication's Goal: Action!

It should be clear by now that the purpose of industrial communication

*Vice president, Sinclair Oil Corporation, New York, New York.

†Presented to a session on training during the 20th Midyear Meeting of the American Petroleum Institute's division of refining, in the Jefferson Hotel, St. Louis, Missouri, May 9, 1955.

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is not merely the transmission of facts and information from a dimly known, abstract entity called "management" to a group of people who are to be merely the repositories of such facts. The unchanging goal of communication in industry is, first, to reach the understanding of the people and, second, get the people to respond to the message—demonstrating their response by effective, cooperative action. The "effective, cooperative action" which management seeks is quite simple to express: Management desires its employees: 1, To *want* to do their best work; and, 2, to strive to do it. It is really as simple as that. (In days gone by it was called "efficiency"; but efficiency is a word which many people avoid using in connection with employee relations, these days.)

What I want to emphasize is that communicating just for the sake of communicating is a mistake. Yet many companies do it. Let us keep in mind that the communication *I* am discussing is the kind which is a means or an instrument for achieving cooperative, willing effort on the part of the employees. It must be regarded as a part of the whole employee-relations package. It is an important, vital part of employee relations—but it is not the whole package, and should never exist just for its own sake. If we succeed in gaining a common perspective on this one point, you and I will, I'm sure, be in general agreement on my main premise: That *supervision* is the key to effective communication; that, unless supervision is allowed—no, *required* —to fill its correct slot in employee communications, the most ambitious other types of communications will fail.

First, let's see why written or filmed or other visual communications should not be expected to carry the whole burden—or even the main burden of management-employee communications. Well, for one thing, all forms of human communication other than face-to-face talk are substitutes. Radio, television, letters, telegrams, magazines —all are substitute ways which the message sender uses because he cannot communicate face-to-face. In the same category, business memoranda, bulletins, house organs, employee manuals, and public-address systems are adopted by management men because they cannot possibly present their message or tell their story to employees individually and in person.

My contention is that, in the delicate area of management-employee communication, an impersonal subsitute can be a dangerous device to rely on as the exclusive medium of creating mutual understanding. Not that it is impossible to be misunderstood in face-to-face transactions. That can and does happen every day. But precisely because there is always this risk of being misunderstood or only partly understood, we in management should seek to reduce the risk, and should avoid relying exclusively on media which can be "interpreted" or distorted. We know, for instance, that two people of the same intelligence can get entirely different impressions from the same newspaper story. Similarly—and to a greater extent—employees can "read between the lines" things which were never intended when the employer composed and dictated his bulletin or memo. If he were there to explain and to answer questions, it would be unlikely to happen—but, in his absence, the piece of paper cannot answer for him, or correct wrong impressions.

Personal Communication Ideal

There is another reason why reliance on substitute media to carry all of management's messages is ineffective. We are living in a skeptical age. People generally are less inclined to accept what they read on its face. Often, therefore, a company publication is received as "management propaganda." For some reason or other, both those words in combination seem to portray something to suspect. Actually, of course, there is nothing wrong with "propaganda" or propagandizing — it means nothing more than spreading the word. The word "management" runs into trouble because it is an abstraction. It is a collective word that, unfortunately, never is thought of as representing a group of flesh-and-blood individuals who have their own personal problems in addition to the hundreds of crucial business problems they must solve every day. So, on two counts, such substitute media as bulletins, house organs, etc., must be rejected as the exclusive ways to communicate:

1. They are impersonal.
2. Employees tend to suspect the motives behind them.

In combination with correct management attitudes being personally and skillfully communicated, written and graphic media can successfully supplement such personal communication efforts, however.

Now, who is to assume this personal communication task in behalf of management? Obviously it must be management itself. But how can the owner or president of a company possibly convey his messages in person? The answer is, of course, he can't—neither can most of his top associates. They just cannot divert the time from their decision-making functions in order to get around among the employees every time they should. Well, in that case, how have they "managed" their employees' work? By establishing a whole class of management individuals called "supervision." These people constitute the only day-in day-out management communicators who can get the employee to understand management and go on from there to win responsive, effective, cooperative action. In fact, for most employees, these are about the only "management" the employee gets to talk to regularly.

Supervision is indeed—as we have all contended—genuine, face-to-face management. Unfortunately it took a "high-court" decision to make some of us fully realize that our supervisors and foremen were more than the "traffic cops of industry." But, in the almost 10 years which have ensued, we have progressed substantially toward making them truly members of the management group. There is still much to be accomplished, however, and a great part of what needs to be done can, in my opinion, be achieved by greater recognition of the supervisors' role in management-employee communications.

The supervisor's day's work is, in fact, devoted to communication. The "instruments" of his daily work are the people he supervises. His skills are not merely to be found in his knowledge of the group's work goals —they extend, rather, to his capacity for getting his people to recognize the goals, have the *will* to achieve them, and then *work* to achieve them. To express it by a comparison: Top management's skills are exercised in arriving at sound business decisions; front-line management displays its skills when it gets its subordinates to go into action in furtherance of those decisions. Clearly, if top management does not effectively communicate its own decisions and business goals to the supervisor, he cannot direct his people properly. Equally clearly, if the supervisor does not communicate effectively to the specific work group, they cannot efficiently put out the product or render the service, as management wants it done. It seems apparent, therefore, that there must be clear, definite communication from top management to supervision, and from supervision to the rank and file.

No Leadership Without Effective Communication

But clarity and definiteness are not enough. The rank and file may understand fully what is wanted. But that does not mean that they will put forth their best work effort in order to accomplish it. It is in this area that another phase of supervision's communications role comes into play, viz., in the supervisor's human relations—in the

manner in which he deals with his people. And dealing with people is nothing more nor less than communicating with them. Have you ever noticed how frequently we evaluate a member of supervision in these exact terms: "Sure knows the job. Knows how to handle people." More and more, we of industrial management have tended to put the emphasis on the second quality —"knows how to handle people." Now "handling people" doesn't mean anything except *dealing* with them, *communicating* with them. Thus the key qualification of supervision is the capacity to communicate . . . to communicate ideas, knowledge, objectives, understanding . . . but, above all, enthusiasm, encouragement, and the will to turn out more and better work.

One all-embracing word to cover this communication role is "leadership." Unless he can communicate effectively, the supervisor can never lead. Unless he can lead, it is useless for him to try to communicate. The two go hand in hand.

Now how can management make sure that its supervision is *leading* effectively? One way—and it is a familiar one—is to require frequent, systematic reports from each supervisor. This accomplishes two things: It informs management, of course; and, in addition, it puts the supervisor into the mainstream of company communications. If the results reflected by such reports are not up to expectations, middle or higher management can take a look to find out why. If the reports do not accurately reflect what is actually being accomplished in the work unit, it will not be long before any variance from the facts will be exposed. So that, in the sense of routine work communication, it is obvious that the supervisor plays a key part.

But what of employee attitudes? you may ask. How does the supervisor fit in there? My answer is that, by and large, employee attitudes—or morale, if you wish—will be determined in greater measure by the supervisor's skill in handling his people than by any other means available to management. It is he who has to give the orders and see that they are executed. It is he who has to commend or criticize the employee. The manner in which he does either will strongly influence the work group's morale. If he is a bull o' the woods, out of tune with top management's way of conveying its wishes, then all the morale publications which can be printed won't improve the employee's evaluation of management — unless they happen to like a bull o' the woods-type boss . . . and some people do! If he is the overconsiderate type, who is so preoccupied with the "good-feelings" of his subordinates that he doesn't care about work goals, then all the cost consciousness campaigns which management may undertake will be a waste of time so far as that group is concerned.

This spells out the need for meticulous selection of candidates for promotion to supervisory jobs. It indicates that it is not enough that a man be a producing demon as a rank-and-filer in order to qualify him for supervision. Nor does an inefficient man who has the gift of getting along with people meet my ideal of supervision. What we must look for is a balance of qualifications—never settling for a man with weaknesses that seem beyond strengthening. And one of the key ingredients in the candidate for supervisor is the twofold virtue of being able to understand management and to communicate that understanding to his subordinates.

Supervisors Lateral Communications

At this point, let us note that the supervisor has lateral communication functions in addition to those with upper management and with his subordinates. If his modes of communication with supervisors at the same level but in other units are not good, we are apt to find internal warfare developing. Friendly rivalry between departments or units is one thing; cut-throat is quite another. Unless there is a feeling of mutual respect based on mutual understanding at this communication stage, we shall not have overall effective, cooperative action.

Many a time we have seen a company held back because one department was feuding with a neighbor. The reason usually is that the company's general goals are being ignored in the interdepartmental competition. The goals of the specific group overshadow the company's objectives. If top management takes a hand when it detects such a development, however, it can, by establishing sound communications, give proper direction to these misspent energies. And, obviously, the place to begin this communication therapy is with the supervisors of each group. Here we have another illustration of the key situation of supervision in industrial communication.

To what extent should supervision participate in the origination of communication? Assuming, for example, that top management wishes to inform employees of some new policy, how should supervision be integrated into the preparation and publication of it? That can best be answered by reminding ourselves of one important fact: *Supervision represents the best fact-finding agency in the company*. If the management wishes to have an accurate forecast of what employee reaction is going to be, it need look only to its supervisors for it. If it is seeking the best method of publicizing the new policy, its supervisors can probably furnish the answer. If there is some doubt as to how effective certain language will be in getting cooperation with the new policy, again the supervisor can make good suggestions.

Naturally top management cannot be running to supervision every time it wishes to issue a bulletin. But, where it does get supervision's help in planning the communication procedure and content, it's a certainty that the supervisors who participated at the point of origin will be enthusiastic in backing up management's position—because it is their own position. Whether you will want to bring supervision in to help make such decisions will depend, of course, on the content of the communications and the amount of help you think the supervisors may be able to give. But bear this in mind, if you will: If there are two or more supervisors of equal standing in the organization and the communication affects all their groups, it may be disastrous to leave any of them out of the discussions unless you are able to give a sound explanation for such omission to the "left-out" supervisor.

In much the same connection, how often have we not seen supervisors dropped several pegs in stature because their subordinates had been "given the word" before the supervisors themselves were informed. It matters little whether the employees' source was the grapevine or an overheard scrap of conversation. There is nothing which can more quickly destroy or impair a supervisor's feelings of leadership than to find that his people are better, or sooner, informed about management matters than he is. Ideally, to prevent this, there should be careful dissemination of management information down the management pyramid—with no level being given the information before a higher level has been informed. This particularly applies to major changes in the organization or its activities. In lesser degree it is true of minor management decisions.

Supervisor's "Split Personality"

It may seem that I am treating too seriously this business of loss of stature by the supervisor. In my judgment, the individual supervisor's standing must be sustained perpetually. Otherwise it is inconsistent to keep telling supervisors that they are "members of the management team" and that we expect them to devote their loyalties to the company. A supervisor who has to endure the split personality that re-

sults from being told he is a management man, on the one hand, and then in practice not being treated as such, cannot be expected to be an undivided person when we need his total efforts to help us in tight situations. We of management resented it when the "court" told us that foremen and supervisors were merely the traffic cops of industry. We should not, in practice, make them so through our thoughtlessness.

Once a company has committed itself to the philosophy that its communication efforts depend intimately on the communication skill of its supervisors, we can be certain that the "formal" communication programs have a good chance of success. One reason is that the house newspapers, the manuals, the bulletins, will be read by an audience of employees who are more receptive to what top management has to say, because they have been affirmatively conditioned by the front-line branch of management. They are more prepared to accept management's published professions of good will, because they have seen it in living example every day. Where supervision has been skillfully building sound human relations in the daily work, through good face-to-face communications, it will be almost impossible for the published material not to be enthusiastically received.

I recognize that this seems to be the hard way to communicate. It seems so much easier to call in a consultant and ask him to set up a slick communications "program." It is easier—no question about it! It is also fairly simple—and inexpensive—to find some talented young person in your organization who can turn out an acceptable house paper. But these will be like "the seed on the rock" in the Bible, if your supervisors haven't developed positive attitudes among your rank and file. Yes, making supervision the basis of your employee communications is indeed the long, hard way. But it is the only permanent way—the only truly effective way.

And it is so rewarding to succeed in industrial communications. There is such a story to tell of the contributions of American business. There is so much that can be gained by having employees "identify"—as the expression has it—by having them recognize the mutual interdependence of employer and employee. Without such recognition by an employee, we cannot count on getting more than a small piece of his potential energy and interest in his job. We of management who have been successful in our administration of the materials, the money, the machines, the marketing of American products and services, have only in recent years risen to the challenges presented by employee administration. We seem to be on our way toward success in personnel management now, mainly because we have devoted our management skill to improving communications with the people who put top management's plans into execution. But, as in all areas of American business, we shall always find room for further improvement. This is so because there will always be new ideas to communicate, and we shall be continually seeking new, exciting means of communicating them. These new means of communication which management is sure to develop will, of course, have to keep pace with business progress, and we can expect they will be novel and dramatic. But they cannot be effective by themselves. Their success or failure will always depend on how well management has been communicating face-to-face on the job each day. And we have seen that the face-to-face communicator for management is the supervisor. He alone offers the key to effective communication. As we improve his techniques, we will improve our employee communications. And, as we improve communications, we enlarge our opportunities for greater employee contributions to business progress. * *

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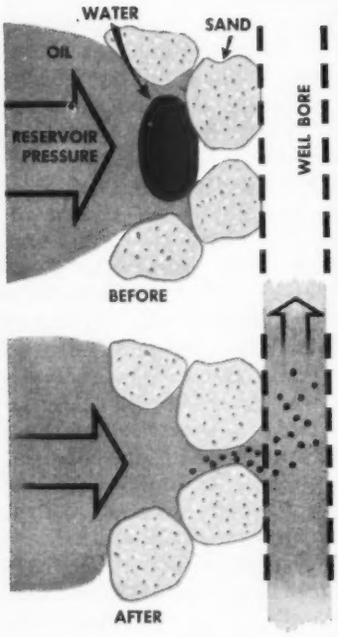

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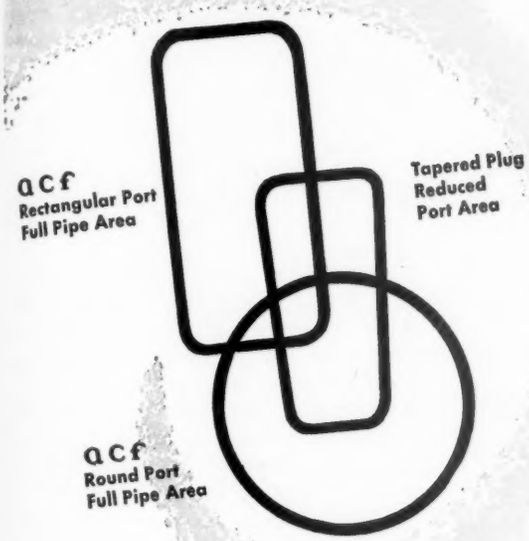

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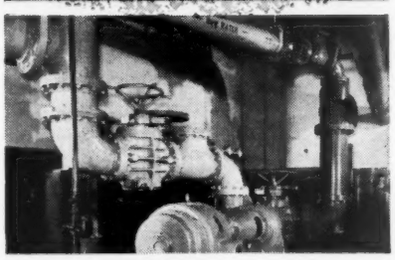

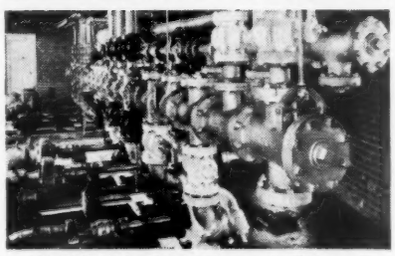

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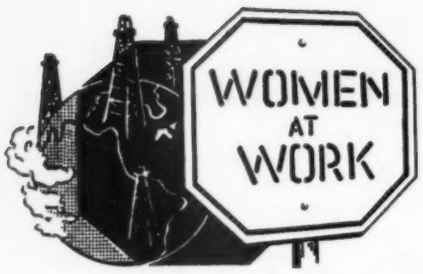

She Helps Transport Gas

Since American women spend most of the money in this country and indeed seem to have a natural bent for spending, purchasing agent is a dream job for many girls. Elizabeth Hector has the job of purchasing agent for Houston Natural Gas Corporation and Houston Natural Gas Production Company, its wholly owned subsidiary.

Elizabeth Hector buys gas supplies.

She does all the buying except stationery and office supplies. She buys field material to carry gas to 17 districts of 93 towns and villages, from Silsbee, Texas, on the north to Falfurrias on the south.

A system such as this is always needing new pipe, plug valves, meters, or regulators; so each week Elizabeth makes one or two trips to the warehouses of principal suppliers, then back to her office in the Petroleum Building in Houston.

She came to Houston from a ranch in Llano, Texas, by way of Austin and the University of Texas. She has worked for Houston Natural Gas for 19 years and has watched it grow from 150 to nearly 1000 employees, and she has grown right along with it.

But it's not "all work and no play" for a woman with Elizabeth Hector's varied interests. Her favorite vacationlands are Mexico and Central America. Many evenings find her in night school, studying Spanish. Other evenings she relaxes in art classes at the University of Houston, the South Texas Junior College, or the Houston Museum of Fine Arts.

Weekends she goes home to Galveston Bay where she fishes and entertains guests. She designed the house herself, which features a 36- by 18-ft living room. Her next project is a long fishing pier out into the bay in front of the house.

Miss Hector is a member of the Desk and Derrick Club of Houston and of the Public Utility Buyers Group of the National Association of Purchasing Agents. In May she appeared on a panel at a meeting of the Southern Gas Association in New Orleans. This was a meeting of 20 gas companies in the southern part of the United States to discuss purchasing problems.

Elizabeth was the only woman on the panel.

Dr. Hutchinson—Chemical Engineer

Dr. Margaret H. Hutchinson has not only made an overwhelming success in a predominantly masculine field. She has also achieved her full share of credit in the role of "women's work." She is a registered professional chemical engineer, recent recipient of the 1955 award of the Society of Women Engineers for Meritorious Contributions to Engineering; she is also the wife of William C. Rousseau, another chemical engineer, the mother of a nine-year-old son, and the lady-of-the-house at the Rousseau home in Reading, Massachusetts, a suburb of Boston.

Margaret is a native Texan. Her early life in Houston was spent in typical little-girl pursuits with no evidences of the woman who was to emerge. She took music, ballet and courses in school that would prepare her for homemaking. In her final year of high school "a talented chemistry teacher opened the windows of my mind to an exciting new world."

Margaret Hutchinson inspects fractionator installation.

She entered Rice Institute as a chemistry major, transferred the following year to the school of Chemical Engineering, the first woman ever allowed to enter. She did not actually encounter any opposition, because the head of the department did not believe in "quibbling" about such a matter. It was plain, though, that most of her professors and classmates wondered at what stage she would come to her senses.

Apparently she never has! She went on to MIT for graduate work, is the only woman ever to be awarded the degree of Doctor of Science in Engineering from that institution. "Again, I remember," she says, "even the more far-sighted professors could see little hope for a woman's becoming actively engaged in a solidly male field."

A sympathetic woman in the administrative department of E. B. Badger & Sons of Boston, designers and builders of chemical plants and oil refineries, persuaded one of their vice presidents to hire young Dr. Hutchinson on a trial basis. Apprehension waned progressively with each project the young woman doctor-of-science turned out. Soon her temporary status had become permanent, and when Badger merged with Stone & Webster Engineering Corporation, Dr. Hutchinson went along. She is still with Stone & Webster as chemical engineering consultant and an authority in the design of distillation equipment. She has collaborated on the design of such plants as high-production peincillin units, antifreeze units, and oil refineries, including the Abadan refinery. She has done research in fractionation and has published some of her findings.

She is the first woman to be admitted to the American Institute of Chemical Engineers, and is the only woman member with the status of "active." She is a member of the Business and Professional Women's Club of Boston.

Margaret Hutchinson and William Rousseau met while working together on a research project. They are still working together, in private life as well as sharing the same profession. Mrs. Rousseau takes time each year to spend several relaxing weeks in Bermuda with her family. Father, mother and son own a small camp on a lake in Maine where they go for summer weekends. The Rousseau's social life is centered around their home and their son.

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LAUGH with BARNEY

"You know that confession story I wrote for that magazine back in New York?"

"Did they buy it?"

"No, but I just got a letter from one of their lady editors, and she's flying all the way out here to meet me, she says."

A bathing beauty is a girl who is worth wading for.

A motorist and his wife traveling through the Blue Ridge Mountains of Tennessee stopped at a one-pump gas station before a mountaineer's cabin. After the man told the proprieter to fill the tank, his wife asked: "Is there a rest room here?"

Attendent: "No, ma'am, there isn't, but you'll find a mighty comfortable rocker up there on the porch."

Doctor (after a thorough examination): Well son, you have a little chest trouble.

Cowboy: Whaddya suggest?

Doctor: Can you arrange to sleep out-of-doors?

Cowboy: Well, I been sleepin' under the old chuck wagon all summer, but I reckon I could kick a couple spokes outa the wheels.

Happiness comes from good health and a poor memory.

"Listen," said one cute young thing to another, concerning a rival, "All a sweater does for her is make her itch!"

A man ran for sheriff in a small western town and after the ballots were counted found that he had been defeated 100 to 1. The day following the election he walked down the center of the main street carrying two guns.

"See here," said an indignant citizen," "You have no right to carry guns. You weren't elected sheriff."

"Listen," he remonstrated, "A man with no more friends than I've got needs these two guns."

Suzi, colored maid (to actress): Miss Fifi, wheah did you eber get that lovely mink coat you is wearin'?

Miss Fifi: Oh, a boy frend of mine who had $2000 gave it to me.

(Several months later)

Miss Fifi: Why, Suzi, you've got a mink coat. Wherever did you get it?

Suzi: Miss Fifi, ah didn't habe no boy frien' wif no $2000, but I did have a thousand boy frend's wif $2 each.

"Simmering in summer, freezing in winter, wind-swept, desolate, inaccessible. . . . In fact, gentlemen, it qualifies in every respect as an ideal spot for an oil field."

Recently we met the most spoiled animal in the world—a rabbit who was an only child.

A bargain is a transaction where two people are sure they got the better of each other.

Teetotaler: The guy who adds your golf score as you are getting ready to drive.

Middle age: When you feel on Saturday night the way you used to feel on Monday morning.

Little boy: Daddy, why do mother's friends always bring their knitting when they come here?

Father: Well, it gives them something to think about while they talk.

Iceman (entering kitchen with cake of ice): Hello, sonny.

Little boy: Hey, when you call me that, smile.

A census taker in the country came upon a farm house and was greeted by a five year old boy.

"How many in your family?" asked the census taker.

"Four," replied the little boy. "There's Mama, daddy, sister and me."

"Where's your Daddy?"

"He's gone fishing, I reckon—I say 'I reckon'—I don't rightly know. But he put on his rubber boots, and it ain't rainin'."

"Where's your mamma, son."

"Well, I guess she's gone out—I don't rightly know. But the catalog's missin,' and she can't read."

"Well, where's your sister, then, little boy?" asked the census taker.

"I reckon she's down at the barn with the hired hand—I say 'I reckon'—I don't rightly know. But there ain't but two things she likes to do—and supper's waitin' on the table."

The driller wrote on the daily log: "Derrick man was drunk today," After sobering up, the derrick man pleaded him to strike out the record. "It's the first time in my life I've been drunk," he pleaded, "and I promise I'll never do it again."

"In this log we write only the truth," said the driller.

At the end of the following day's tour, the derrick man scrawled at the bottom of the log: "Driller was sober today."

"I've sacrificed everything I had in order that you could study medicine," the irate father told his son, "and now that you are a doctor, you tell me I have to give up smoking."

Young man to draft board: "But you can't turn me down. I've proposed to three girls, told my boss what I think of him and sold my car."

There are a lot of things we like about the football season. Aside from everything else, it's the only time of the year a fellow can walk down the street with a blanket on one arm and a girl on the other without having people ask so many fool questions.

Census Taker: How many bushels of corn did you raise last year?

Backwoodsman: Didn't bushel it—bottled it.

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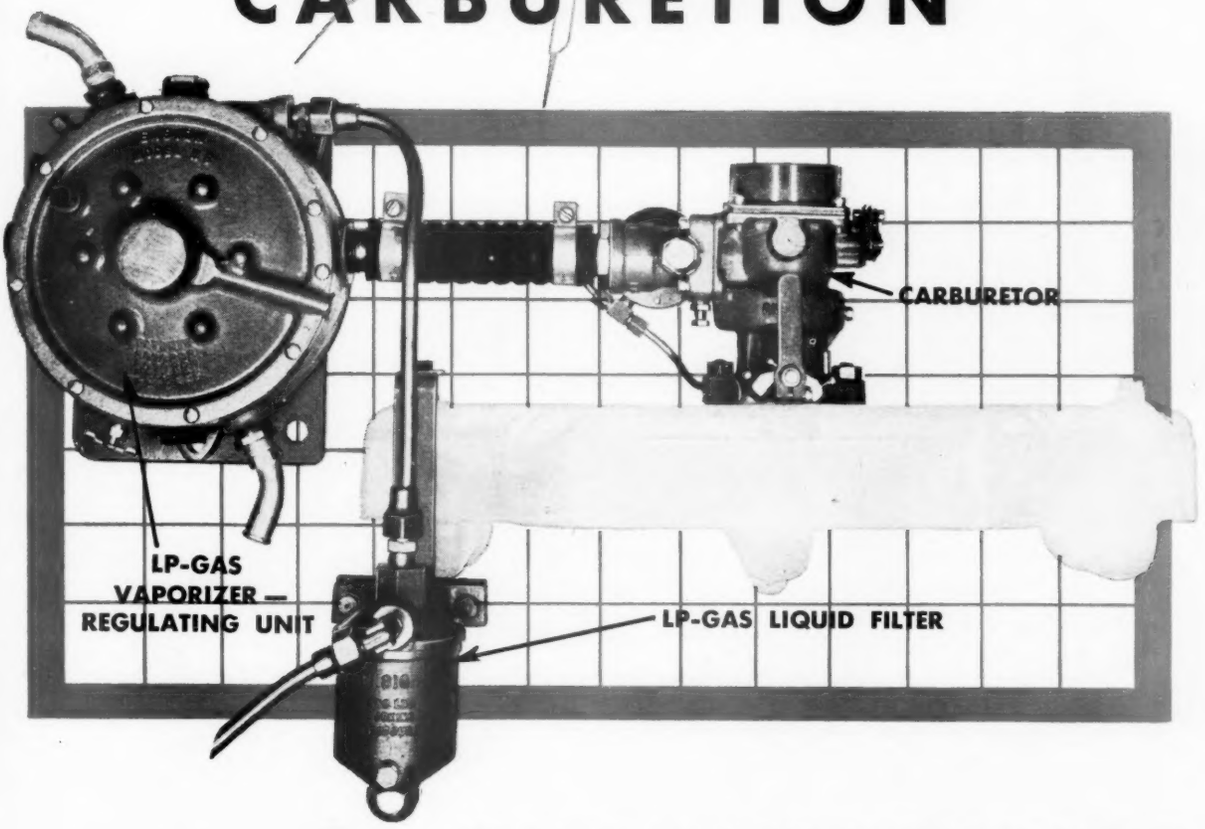

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Directory of

Instruments and Automatic Equipment

for the Petroleum Industry

AUTOMATION plays one of its most important roles in the petroleum industry. In this directory is collected a list of leading manufacturers that produce instruments and automatic equipment which are used by the petroleum industry.

Under the name of each piece of equipment is a list of the companies manufacturing that particular item. On this page are the addresses of all the companies in the directory.

Instruments and automatic equipment are divided into three branches of the industry: Exploration, Drilling, Producing; Refining and Processing, and Oil and Gas Pipelining.

This will make a quick reference for those interested in automatic equipment for specific operations.

Manufacturers of instruments and automatic equipment used in petroleum operations

A-1 Bit & Tool Co., Inc., 9000 Almeda Rd., Houston, Texas
American Machine & Metals, Inc., U. S. Gauge Div., Sellersville, Pa.
American Meter Co., 1513 Race St., Philadelphia 2, Pa.
Associated Research, Inc., 3758 W. Belmont Ave., Chicago 18, Ill.
Baroid Division, National Lead Co., 2404 Danville Rd., Houston, Texas
Barton Instrument Corp., 1429 S. Eastern Ave., Los Angeles 22, Calif.
Beckman Instruments, Inc., Beckman Div., Fullerton, Calif.
B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.
Black, Sivalls & Bryson, Inc., 7500 E. 12th St., Kansas City 26, Mo.
Oilfield Equipment Div., 1708 W. Main St., Oklahoma City, Okla.
Controls Division, 15 N. Cincinnati, Tulsa, Okla.
S. R. Bowen Co., 11008 S. Norwalk Blvd., Santa Fe Springs, Calif.
Bristol Company, Waterbury 20, Conn.
Byron Jackson Co., 492 E. Union St., Pasadena, Calif.
Camco Inc., 7010 Ardmore, Houston 21, Texas
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.
Control Engineering Corp., Controls Div., 934 Wash. St., Norwood, Mass.
Crosby Steam Gage & Valve Co., Ashton Valve Co., 43 Kendrick St., Wrentham, Mass.
Dale Co., 1237 W. 15th St., Long Beach 13, Calif.
Daniel Orifice Fitting Co., Inc., 3352 Union Pacific Ave., Los Angeles, Calif.
Eastman Oil Well Survey Co., 1360 Speer Blvd., Denver, Colo.
Electric Auto-Lite Co., Instrument & Gauge Div., Toledo, Ohio
Falstrom Co., 99 Falstrom Court, Passaic, N. J.
Fisher Governor Co., Marshalltown, Iowa
Foster Engineering Co., 835 Lehigh Ave., Union, N. J.
Foxboro Co., Foxboro, Mass.
Gadco Products Inc., 15 E. Burnett, Long Beach, Calif.
Garrett Oil Tool, Inc., P. O. Box 6115, Houston, Texas
General Electric Co., Apparatus Sales Div., 1 River Rd., Schnectady 5, N. Y.
Grant Oil Tool Co., 2042 E. Vernon Ave., Los Angeles 58, Calif.
Guiberson Corp., 1000 Forest Ave., Dallas 1, Texas
Halliburton Oil Well Cementing Co., Duncan, Okla.
Hammarlund Manufacturing Co., Inc., 460 W. 34th St., New York 1, N. Y.
Hammel-Dahl Co., Warwick Industrial Park, Providence 5, R. I.
Hays Corp., 742 E. 8th St., Michigan City, Ind.
Jerguson Gage & Valve Co., 87 Fellsway, Somerville 45, Mass.
Kobe, Inc., 3040 E. Slauson Ave., Huntington Park, Calif.
Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa.
L-K Pump Valve Co., 632-640 N. Edgewood, Houston, Texas
Liquidometer Corp., 41-03 36th St., Long Island City, N. Y.
J. E. Lonergan Co., 2nd & Race St., Philadelphia 6, Pa.
Magnetrol, Inc., 2110 S. Marshall Blvd., Chicago 23, Ill.
Manning Maxwell & Moore, Inc., 250 E. Main St., Stratford, Conn.
Jas. P. Marsh Corp., 3501 Howard St., Skokie, Ill.
Martin-Decker Corp., 3431 Cherry Ave., Long Beach 7, Calif.
Mason-Neilan Regulator Co., 1204 Adams St., Boston 24, Mass.
Meriam Instrument Co., 10920 Madison Ave., Cleveland 2, Ohio
Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Aves., Philadelphia 44, Pa.
Neptune Meter Co., 19 W. 50th St., New York 20, N. Y.
Oil Well Supply, 2001 N. Lamar St., Dallas, Texas
Otis Pressure Control, Inc., P. O. Box 7206, Dallas, Texas
Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill.
Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio
Penn Instruments Div., Burgess-Manning Co., 4110 Haverford Ave., Philadelphia 4, Pa.
Perkin-Elmer Corp., Norwalk, Conn.
Petroleum Instrument Co., 2200 W. Alabama, Houston, Texas
Radio Corporation of America, Camden 2, N. J.
Raytheon Mfg. Co., 100 River St., Waltham, Mass.
Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland 10, Ohio
Republic Flow Meters Co., 2240 W. Divsersey Ave., Chicago 47, Ill.
Robinson Orifice Fitting Co., 2830 Lugo St., Los Angeles 23, Calif.
Robinson Orifice Fitting Co. of Texas, P. O. Box 17216, Houston, Texas
Rolo Manufacturing Co., P. O. Box 6763, Houston 5, Texas
Shutte and Koerting Co., Cornwells Heights, Bucks County, Pa.
Shand & Jurs Co., 8th & Carelton Sts., Berkeley 10, Calif.
Sperry-Sun Well Surveying Co., P. O. Box 8008, Houston, Texas
Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio
Taylor Instrument Companies, 95 Ames St., Rochester 1, N. Y.
Technical Oil Tool Corp., 1057 N. LaBrea Ave., Los Angeles 38, Calif.
Tracerlab, Inc., 130 High St., Boston 10, Mass.
Trinity Equipment Corp., 472 Westfield Ave., E. Roselle Park, N. J.
Vapor Recovery Systems Co., 2820 N. Almeda St., Compton, Calif.
Vernon Tool Co., Ltd., 1101 Meridan Ave., Alhambra, Calif.
Wallace & Tiernan, Inc., 25 Main St., Belleville 9, N. J.
Electro Rust-Proofing Corp., 30 Main St., Belleville 9, N. J.
Weston Electrical Instrument Corp., Newark 5, N. J.
Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, Pa.

Chemical Feeders

B-I-F Industries, Inc.
Black, Sivalls & Bryson

Controllers and Regulators

MECHANICAL

American Meter Co.
B-I-F Industries, Inc.
Black, Sivalls & Bryson
Fisher Governor Co.
Foster Engineering Co.
Guiberson Corp.
Liquidometer Corp.
Martin-Decker Corp.
Mason-Neilan Regulator Co.
Otis Pressure Control, Inc.
Penn Instruments
Taylor Instrument
Vapor Recovery Systems Co.
Weston Electrical Instrument

HYDRAULIC

B-I-F Industries, Inc.
Fisher Governor Co.
Foster Engineering Co.
Gadco Products Inc.
Hammel-Dahl Co.
Martin-Decker Corp.
Mason Neilan Regulator Co.
Oil Well Supply
Parker Appliance Co.
Penn Instruments
Republic Flow Meters Co.
Rolo Manufacturing Co.

PNEUMATIC

American Machine & Metals
American Meter Co.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Conoflow Corp.
Fisher Governor Co.
Foster Engineering Co.
Foxboro Co.
Hammel-Dahl Co.
Leeds & Northrup Co.
Martin-Decker Corp.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Rolo Manufacturing Co.
Taylor Instrument Companies
Wallace & Tiernan Inc.
Weston Electrical Instrument

ELECTRONIC AND ELECTRIC

B-I F Industries, Inc.
Fisher Governor Co.
Foster Engineering Co.
General Electric
The Hammarlund Mfg. Co.
Hays Corp.
Leeds & Northrup Co.
Manning Maxwell & Moore
Minneapolis-Honeywell
Penn Instruments
Reliance & Electric Eng. Co.
Vapor Recovery Systems Co.
Weston Electrical Instrument

Flow Controllers

A-1 Bit & Tool Co., Inc.
American Meter Co.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
S. R. Bowen Co.
Bristol Co.
Foxboro Co.
Guiberson Corp.
Hays Corp.
Kobe Inc.
L-K Pump Valve Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Taylor Instrument Companies

Flow Meters

DRY TYPE

American Meter Co.
Barton Instrument Corp.
Bristol Co.
Foxboro Co.
Hays Corp.
Minneapolis-Honeywell
Penn Instruments
Taylor Instrument Companies

MERCURY U-TUBE

American Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Foxboro Co.
Mason Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Taylor Instrument Companies

SINGLE STREAM

B-I-F Industries, Inc.
Foster Engineering Co.
Foxboro Co.
Guiberson Corp.
Neptune Meter Co.
Penn Instruments

FULL BORE

Foster Engineering Co.
Penn Instruments

ORIFICE

Daniel Orifice Fitting Co.
Robinson Orifice Fitting Co.
Robinson Orifice of Texas

REMOTE INDICATION AND INTEGRATION

American Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Fisher Governor Co.
Foxboro Co.
The Hammarlund Mfg. Co.
Hays Corp.
Leeds & Northrup Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Taylor Instrument Companies

MASS FLOW

Control Engineering Corp.

Flow Recorders

ELECTRICAL

B-I-F Industries, Inc.
Bristol Co.
Foxboro Co.
Hays Corp.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Rolo Manufacturing Co.

MECHANICAL

American Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Dale Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Neptune Meter Co.
Penn Instruments
Taylor Instrument Companies

Gas Indicators and Analyzers

Baroid, National Lead Co.
Hays Corp.
Leeds & Northrup Co.
Mine Safety Appliances
Petroleum Instrument Co.

Intermitter Controls

Camco Inc.
Fisher Governor Co.
Garrett Oil Tools
Guiberson Corp.

Liquid Level Gages

American Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Crosby-Ashton
Fisher Governor Co.
Foxboro Co.
Jerguson Gage & Valve Co.
Liquidometer Corp.
Magnetrol, Inc.
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Petroleum Instrument Co.
Shand and Jurs Co.
Taylor Instrument Companies
Vapor Recovery Systems Co.
Wallace & Tiernan Inc.
Yarnall-Waring Co.

Measurement Equipment

American Meter Co.
Eastman Oil Well Survey Co.
Foxboro Co.
General Electric Co.
Halliburton Oil Well
Rolo Manufacturing Co.

Mud Testing

Baroid, National Lead Co.

pH-Indicators, Recorders, Controllers

Baroid, National Lead Co.
Beckman Instruments
Bristol Co.
Foxboro Co.
Leeds & Northrup Co.
Minneapolis-Honeywell
Shand & Jurs Co.
Weston Electrical Instrument

Pressure Gages

American Machine & Metals, Inc.
American Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Crosby-Ashton
Fisher Governor Co.
Foxboro Co.
General Electric Co.
Hays Corp.
J. E. Lonergan Co.
Manning Maxwell & Moore, Inc.
Jas. P. Marsh Corp.
Martin-Decker Corp.
Minneapolis-Honeywell
Taylor Instrument Companies
Wallace & Tiernan Inc.

Pressure Recorders

American Machine & Metals, Inc.
American Meter Co.
Beckman Instruments
B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Crosby-Ashton
Electric Auto-Lite Co.
Foxboro Co.
Hammel-Dahl Co.
Hays Corp.
Manning Maxwell & Moore Inc.
Martin-Decker Corp.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Taylor Instrument Companies
Wallace & Tiernan Inc.
Weston Electrical Instrument

Regulating Units

(Operate with automatic controllers)

American Meter Co.
B-I-F Industries, Inc.
Fisher Governor Co.
Foxboro Co.
General Electric Co.
Guiberson Corp.
Hammel-Dahl Co.
Minneapolis-Honeywell
Penn Instruments
Reliance Electric & Eng. Co.
Taylor Instrument Companies
Weston Electrical Instrument

Remote Controllers and Transmission

American Meter Co.
Beckman Instruments
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Fisher Governor Co.
Foxboro Co.
Garrett Oil Tools
General Electric Co.
Guiberson Corp.
Hammarlund Mfg. Co., Inc.
Manning Maxwell & Moore Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Reliance & Electric Eng. Co.
Republic Flow Meters Co.
Taylor Instrument Companies
Vapor Recovery Systems Co.

Safety Heads

Black, Sivalls & Bryson, Inc.

Safety Valves

A-1 Bit & Tool Co.
Grant Oil Tool Co.
Otis Pressure Control Inc.

Speed Controllers

Martin-Decker Corp.

Tachometers

Martin-Decker Corp.

Temperature Gages and Recorders

American Machine & Metals, Inc.
Beckman Instruments
Bristol Co.
Control Engineering Corp.
Dale Co.
Electric Auto-Lite Co.
Foxboro Co.
Hays Corp.
Leeds & Northrup Co.
Manning Maxwell & Moore, Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Shand & Jurs Co.
Trinity Equipment Corp.
Taylor Instrument Companies
Weston Electrical Instrument

Torque Gages Recording

Martin-Decker Corp.

Weight Indicators and Torque Gages

Control Engineering Corp.
General Electric Co.
Martin-Decker Corp.
Minneapolis-Honeywell

Well Logging Units

Baroid, National Lead Co.

Well Surveying Instruments

Eastman Oil Well Survey Co.
Sperry-Sun Well Surveying Co.
Technical Oil Tool Corp.

Analytical Control Instruments

Beckman Instruments
Consolidated Engineering Co.

Boiler Control

Black, Sivalls & Bryson Inc.
Hays Corp.
Magnetrol Inc.
Minneapolis-Honeywell
Republic Flow Meters Co.
Weston Electrical Instrument

Boiler Water-Level Indicators

MECHANICAL

Black, Sivalls & Bryosn Inc.
Jerguson Gage & Valve Co.
Magnetrol Inc.
Meriam Instrument Co.
Yarnall-Waring Cc.

PNEUMATIC

Black, Sivalls & Bryson, Inc.
Hammel-Dahl Co.

ELECTRIC

Control Engineering Corp.

Chemical Pressure Gages

American Machine & Metals
Bristol Co.
Control Engineering Corp.
Crosby-Ashton
J. E. Lonergan Co.
Manning Maxwell & Moore Inc.
Taylor Instrument

Coke Level Indicators

Tracerlab, Inc.

Conductivity—Indicators, Recorders, Controllers

Bristol Co.
Foxboro Co.
General Electric Co.
Leeds & Northrup Co.
Minneapolis-Honeywell

Control Transmission Systems—Radio

Radio Corp. of America
Raytheon Mfg. Co.

Controllers and Regulators

MECHANICAL

American Meter Co.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Fisher Governor Co.
Foster Engineering Co.
Mason-Neilan Regulator Co.
Penn Instruments
Shand & Jurs Co.
Vapor Recovery Systems Co.
Weston Electrical Instrument

HYDRAULIC

Gadco Products, Inc.
Fisher Governor Co.
Foster Engineering Co.
Hammel-Dahl Co.
Mason-Neilan Regulator Co.
Parker Appliance Co.
Penn Instruments
Republic Flow Meters Co.
Shand & Jurs Co.

PNEUMATIC

American Machine & Metals
American Meter Co.
B-I-F Industries Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Conoflow Corp.
Fisher Governor Co.
Foster Engineering Co.
Foxboro Co.
Hammel-Dahl Co.
Leeds & Northrup Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Taylor Instrument
Wallace & Tiernan Inc.
Weston Electrical Instrument

ELECTRONIC AND ELECTRIC

B-I-F Industries, Inc.
General Electric Co.
Fisher Governor Co.
Foster Engineering Co.
The Hammarlund Mfg. Co.
Hays Corp.
Leeds & Northrup Co.
Manning Maxwell & Moore Inc.
Minneapolis-Honeywell
Penn Instruments
Reliance Electric & Eng. Co.
Swartwout Co.
Vapor Recovery Systems Co.
Weston Electrical Instrument

Flow Controllers

American Meter Co.
B-I-F Industries, Inc.
Black, Sivalls & Bryson
Bristol Co.
Fisher Governor Co.
Foxboro Co.
Hays Corp.
L-K Pump Valve Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Schutte & Koerting Co.
Swartwout Co.
Taylor Instrument

Flow Meters

DRY TYPE

American Meter Co.
Barton Instruments
B-I-F Industries Inc.
Bristol Co.
Foxboro Co.
Hays Corp.
Minneapolis-Honeywell
Penn Instruments
Taylor Instrument

MERCURY U-TUBE

American Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Taylor Instrument

SINGLE STREAM

Foster Engineering Co.
Penn Instruments
Schutte & Koerting Co.

FULL BORE

Foster Engineering Co.
Penn Instruments

PIPE LINE

Orifice

American Meter Co.
Barton Instruments
Bristol Co.
Control Engineering Co.
Daniel Orifice Fitting Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Robinson Orifice Fitting Co.
Robinson Orifice of Texas
Swartwout Co.
Taylor Instrument Companies

Pitot Tube

Bristol Co.
Control Engineering Corp.
Foxboro Co.
Meriam Instrument Co.
Penn Instruments

Venturi

B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Foxboro Co.
Minneapolis-Honeywell
Penn Instruments

REMOTE INDICATION AND INTEGRATION

Bristol Co.
Byron Jackson Co.
Control Engineering Corp.
Foxboro Co.
The Hammarlund Mfg. Co.
Hays Corp.
Magnetrol Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Panellit Inc.
Penn Instruments
Republic Flow Meters Co.
Schutte & Koerting Co.
Shand & Jurs Co.
Taylor Instrument

Flow Recorders

ELECTRICAL

B-I-F Industries Inc.
Bristol Co.
Consolidated Engineering Co.
Control Engineering Corp.
Foxboro Co.
Hammarlund Mfg. Co., Inc.
Hays Corp.
Minneapolis-Honeywell
Panellit Inc.
Penn Instruments
Republic Flow Meters Co.
Swartwout Co.
Tracerlab, Inc.

MECHANICAL

American Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Consolidated Engineering Co.
Foxboro Co.
Hammarlund Mfg. Co., Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Schutte & Koerting Co.
Taylor Instrument

Gas Indicators and Analyzers

Hays Corp.
Leeds & Northrup Co.
Mine Safety Appliances Co.
Perkin-Elmer Corp.

Liquid Level Gages

CLOSED VESSELS

Barton Instruments
B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Crosby-Ashton
Jerguson Gage & Valve Co.
Foxboro Co.
Liquidometer Corp.
Magnetrol Inc.
Mason-Neilan Regulator Co.
Meriam Instrument
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Shand & Jurs Co.
Taylor Instrument
Vapor Recovery Systems
Wallace & Tiernan Inc.
Yarnall-Waring Co.

Instrument and Control Panels and Cubicles

Falstrom Co.

Measurement Equipment

Central Scientific Co.

pH—Indicators, Recorders, Controllers

Baroid Div.
Beckman Instruments
Bristol Co.
Foxboro Co.
Leeds & Northrup Co.
Mine Safety Appliance Co.
Minneapolis-Honeywell
Panellit Inc.
Shand & Jurs Inc.
Weston Electrical Instrument

Pressure Gages

American Machine & Metals
American Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Byron Jackson Co.
Consolidated Engineering Co.
Control Engineering Corp.
Crosby-Ashton
Foxboro Co.
General Electric Co.
Hays Corp.
J. E. Lonergan Co.
Manning Maxwell & Moore Inc.
Jas. P. Marsh Corp.
Minneapolis-Honeywell
Taylor Instrument
Wallace & Tiernan Inc.

Pressure Recorders

American Machine & Metals
American Meter Co.
Beckman Instruments
B-I-F Industries, Inc.
Bristol Co.
Byron Jackson Co.
Control Engineering Corp.
Crosby-Ashton
Electric Auto-Lite Co.
Foxboro Co.
Hammel-Dahl Co.
Hays Corp.
Manning Maxwell & Moore Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Panellit Inc.
Penn Instruments
Republic Flow Meters Co.
Swartwout Co.
Taylor Instrument
Weston Electrical Instrument

Program-Process Control

Beckman Instruments
B-I-F Industries, Inc.
Bristol Co.
Byron Jackson Co.
Consolidated Engineering Co.
Control Engineering Corp.
Foxboro Co.
Hammarlund Mfg. Co., Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Panellit Inc.
Penn Instruments
Taylor Instrument
Weston Electrical Instrument

Process Controls

Black, Sivalls & Jackson, Inc.
Panellit Inc.

Safety Heads

Black, Sivalls & Jackson, Inc.

Safety Valves

Crosby-Ashton

Shut-Down Valve

Black, Sivalls & Bryson
Vernon Tool Co., Ltd.

Stream Blenders

B-I-F Industries, Inc.

Tachometers

Martin-Decker Corp.

Temperature Gages and Recorders

American Machine & Metals
Beckman Instruments
Bristol Co.
Control Engineering Corp.
Electric Auto-Lite Co.
Foxboro Co.
Leeds & Northrup Co.
Manning Maxwell & Moore Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Shand & Jurs Co.
Swartwout Co.
Taylor Instruments
Trinity Equipment Corp.
Weston Electrical Instrument

Controllers and Regulators

MECHANICAL

American Meter Co.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Fisher Governor Co.
Foster Engineering Co.
Mason-Neilan Regulator Co.
Penn Instruments
Vapor Recovery Systems Co.
Weston Electrical Instrument

HYDRAULIC

Gadco Products Inc.
Fisher Governor Co.
Foster Engineering Co.
Hammel Dahl Co.
Mason-Neilan Regulator Co.
Parker Appliance Co.
Penn Instruments
Republic Flow Meters Co.
Shand & Jurs Co.

PNEUMATIC

American Machine & Metals
American Meter Co.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Conoflow Corp.
Fisher Governor Co.
Foster Engineering Co.
Foxboro Co.
Hammel-Dahl Co.
Leeds & Northrup Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Taylor Instrument
Weston Electrical Instrument

ELECTRONIC AND ELECTRIC

B-I-F Industries, Inc.
Foster Engineering Co.
General Electric Co.
The Hammarlund Mfg. Co.
Hays Corp.
Manning Maxwell & Moore Inc.
Minneapolis-Honeywell
Penn Instruments
Reliance Electric & Eng. Co.
Swartwout Co.
Weston Electrical Instrument

Flow Controllers

A-1 Bit & Tool Co.
American Meter Co.
B-I-F Industries, Inc.
Black, Sivalls & Bryson
Fisher Governor Co.
Foxboro Co.
Hays Corp.
L-K Pump Valve Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Swartwout Co.
Taylor Instrument Companies

Flow Meters

DRY TYPE

American Meter Co.
Barton Instrument Corp.
Bristol Co.
Foxboro Co.
Hays Corp.
Minneapolis-Honeywell
Penn Instruments
Taylor Instrument

MERCURY U-TUBE

American Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Taylor Instrument

SINGLE STREAM

B-I-F Industries, Inc.
Foster Engineering Co.
Penn Instruments

FULL BORE

Foster Engineering Co.
Penn Instruments

PIPE LINE

Orifice

American Meter Co.
Barton Instrument Corp.
Bristol Co.
Control Engineering Corp.
Daniel Orifice Fitting Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Robinson Orifice Fitting Co.
Robinson Orifice of Texas
Swartwout Co.
Taylor Instrument

Pitot Tube

Barton Instrument Corp.
Bristol Co.
Control Engineering Corp.
Foxboro Co.
Meriam Instrument Co.
Penn Instruments

Venturi

Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Foxboro Co.
Minneapolis-Honeywell
Penn Instruments

REMOTE INDICATION AND INTEGRATION

American Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Control Enginering Corp.
Foxboro Co.
The Hammarlund Mfg. Co.
Hays Corp.
Leeds & Northrup Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Shand & Jurs Co.
Taylor Instrument

Flow Recorders

ELECTRICAL

B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Foxboro Co.
Hays Corp.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Swartwout Co.

MECHANICAL

American Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Taylor Instrument

Liquid Level Gages

American Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Crosby-Ashton
Foxboro Co.
Jerguson Gage & Valve Co.
Liquidometer Corp.
Magnetrol Inc.
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Shand & Jurs Co.
Taylor Instrument
Vapor Recovery Systems Co.
Wallace & Tierhan Inc.
Yarnall-Waring Co.

Gas Indicators and Analyzers

Hays Corp.
Leeds & Northrup Co.
Mine Safety Appliances Co.

Measurement Equipment — soil resistivity

Associated Research Inc.

Pipe Line Surveying Instruments

Sperry-Sun Well Surveying

Pressure Gages

American Machine & Metals
American Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Byron Jackson Co.
Control Engineering Corp.
Crosby-Ashton
Foxboro Co.
General Electric Co.
Hays Corp.
J. E. Lonergan Co.
Manning Maxwell & Moore Inc.
Jas. P. Marsh Corp.
Minneapolis-Honeywell
Taylor Instrument
Wallace & Ternan, Inc.

Pressure Recorders

American Machine & Metals Inc.
American Meter Co.
Beckman Instruments
B-I-F Industries, Inc.
Bristol Co.
Control Engineering Corp.
Crosby-Ashton
Foxboro Co.
Hammel-Dahl Co.
Hays Corp.
Manning Maxwell & Moore Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Swartwout Co.
Taylor Instrument
Wallace & Tiernan Inc.
Weston Electrical Instrument

Remote Controllers and Transmission

American Meter Co.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Control Engineering Corp.
Fisher Governor Co.
Foxboro Co.
General Electric Co.
Hammarlund Manufacturing Co.
Leeds & Northrup Co.
Manning Maxwell & Moore Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Reliance Electric & Eng. Co.
Republic Flow Meters Co.
Swartwout Co.
Taylor Instrument
Vapor Recovery Systems Co.

Safety Heads

Black, Sivalls & Bryson, Inc.

Stream Blenders

B-I-F Industries Inc.

Tachometers

Martin-Decker Corp.

Tank Gages

Control Engineering Corp.
Liquidometer Corp.
Manning Maxwell & Moore Inc.
Meriam Instrument Co.
Shand & Jurs Co.
Vapor Recovery Systems Co.
Weston Electrical Instrument

Temperature Gages and Recorders

American Machine & Metals
Beckman Instruments
B-I-F Industries Inc.
Bristol Co.
Control Engineering Corp.
Foxboro Co.
Leeds & Northrup Co.
Manning Maxwell & Moore Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Shand & Jurs Co.
Swartwout Co.
Taylor Instrument
Trinity Equipment Corp.
Weston Electrical Instrument

"Instrumentation Paces Automation"

Theme of the Instrument Society of America's 10th Annual Instrument-Automation Conference and Exhibit is "Instrumentation Paces Automation." The meeting will be held September 12-16 at mammoth Shrine Exposition Hall and Auditorium, Los Angeles, California, according to Dr. A. O. Beckman, general chairman.

Designed to attract scientific, technical and research personnel, the event will draw industry leaders from Germany, Japan, England, Scandanavia, and South America, as well as from all over the United States.

Exhibit Manager Fred J. Tabery reports that, in addition to the exhibit, there will be more than 325 technical and clinical sessions during the 5-day Conference period.

Experts in the many fields covered will conduct the sessions. Added to the full program of educational sessions, the new Computer Clinic and Data Handling Workshop are this year receiving special attention.

Oil Rides Boom!

Sales and net income show substantial growth in first half of 1955 but profit margins remain low—consumption increase may reach 8 per cent this year over last

Ernestine Adams*

Financial headlines these days go in heavily for "Soaring production—soaring income—soaring profits."

There has never been a boom like this one. Second quarter figures topped the first quarter and exceeded predictions. *The Wall Street Journal* found combined corporate earnings of a large number and variety of companies up 33 per cent in the second quarter of 1955 from the same 1954 period. A survey covering 734 companies in 26 industries made by First National City Bank of New York shows a 31 per cent gain in earnings during the first half of 1955 above the same period last year.

Oil industry financial reports have not exactly soared but they have shown a substantial trend upward in sales and net income. The same survey mentioned above found petroleum companies gained 13 per cent—about the same as utilities—in the second quarter this year over last.

This steady growth is apparently better for the industry and indicates the reason for confidence in petroleum stocks, many of which are now considered of the investment class. There are fewer wide fluctuations in petroleum than in steel, textiles, automobiles, etc.

Based on the reports of 50 companies, (see table) the first half of 1955 gross income was 8½ per cent higher than for the same period in 1954. Net income went up 12 per cent in the same comparison.

Only 7 companies reported less gross income for the first 6 months of 1955 than for 1954 and all of these were off only 1 or 2 per cent except Wilcox Oil Company. Wilcox was off 22 per cent on gross but came up with an impressive 39 per cent gain in net income, as a result of a large cut in operating expenses.

In net returns 11 companies failed to match their 1954 records; 39 firms increased their net, for the first half this year over last.

Dividends were larger for holders of common stock of 22 oil companies in the first half of 1955 and less for only 4 companies. Stock dividends or splits were not uncommon.

It should be pointed out that profits remained about the same percentage of gross operating income in 1955 as they were in 1954. Net returns were 10.3 per cent of gross in 1954 and 10.6 per cent in the first half of 1955. Few industries work on such a low profit margin.

Third quarter sales are expected to remain on the climbing curve. Prices are stable and demand continues to grow as the big consumer—automotive vehicles—continue to increase. About half of all petroleum products are used in transportation.

Consumption increase more than doubled early predictions and this year's gain will probably be around 8 per cent above 1954 demand.

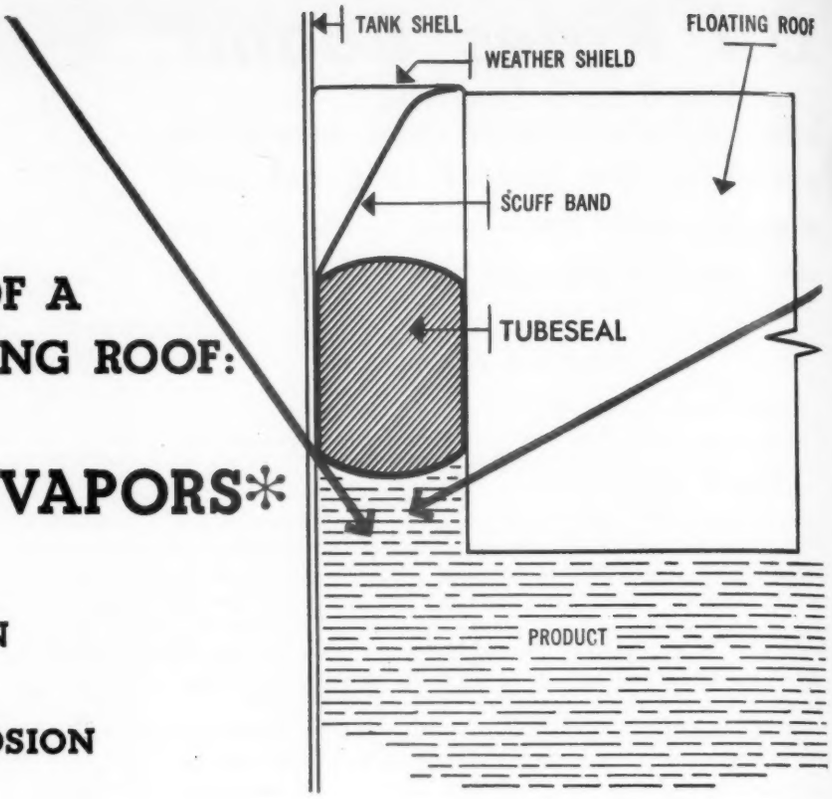
There is no foreseeable reason why petroleum products sales will not hold gains and continue upward. General business predictions by economists for the last half of 1955 and the first half of 1956 are almost uniformly optimistic with a seasoning of hedging. * * *

*Management Editor.

Income of Petroleum Companies for First Half Year, 1955

Company	Gross income $1000	Per cent of 1954	Net income $1000	Per cent of 1954	Dividends first 6 mo. per share common stock 1955	1954
Amerada	50,407	120	5,797	170	2.00	1.50
Anderson-Prichard	28,162	100	1,915	106	.80	.80
Argo Oil	5,845	113	2,070	101	.50	.50
Ashland[10]	121,719	104	5,119	125	.50	.50
Atlantic Ref	259,005	107	18,883	95	1.00	1.00
Aztec Oil	982	134	221	62	0	0
Barber Oil	—	—	14,269[13]	—	1.00	1.00
Bishop Oil	991	111	158	180	.10	.12½
British-American	—	—	9,805	106	.42½	.38¾
Chicago Corp.	31,289	105	3,603	106	.40	.40
Cities Service	453,701	112	23,541	121	1.00	80[14]
Clark O. & R. Co.	27,146	135	762	1468	—	—
Continental	256,565	103	22,172	101	1.40	1.30
Cosden Pet.[15]	50,187	111	3,546	126	.87½	.50
Creole	—	—	144,788	123	2.05[1]	3.50
Crescent Corp	—	—	2,178	[7]	—	—
Douglas Oil	—	—	—	—	.00	.05
Gulf Oil	923,630	109	91,871	114	1.00	1.00
Hancock Oil	—	—	—	—	.30+4%St.	.30[12]
Honolulu Oil	17,320	114	6,195	116	1.00	1.00
Houston Oil	18,188	111	3,739	120	1.00	1.00
Humble Oil	532,426	107	88,284	118	1.14	1.14
Kerr-McGee	—	—	—	—	.28⅛	.00
Lion Oil	58,694	115	7,817	129	1.00	1.00
La. Land & Exp	12,688	102	6,933	101	1.50	1.50
Maracaibo	—	—	—	—	.18	.15
Midwest Oil	6,762	107	2,558	99	.70	.70
Ohio Oil	126,684	99	19,551	100	1.50	1.50
Pacific Western	6,631	99	1,652	59	.00	5%St.
Panhandle Oil	6,216	92	366	73	.15	.15
Phillips Pet	430,016	110	42,576	112	1.50	1.30
Plymouth Oil	49,147	110	3,895	116	.80	.80
Pure Oil	238,053	129	16,081	115	.65[11]	.50
Quaker State	24,791	109	1,208	118	1.00	1.00
Richfield Oil	123,747	121	14,635	118	1.50	1.50
Seaboard Oil	21,078	109	3,544	103	.50	.50
Shamrock Oil	—	—	—	—	1.00	.80[9]
Shell Oil	713,466	109	54,497	86	1.00	87½[1]
Signal Oil	6,593	115	4,080	80	.30	.30
Sinclair Oil	535,591	107	37,801	104	1.30	1.30
Skelly Oil	110,266	105	14,823	105	.90	.80
Socony Mobil	885,687	105	97,056	111	1.00	1.00
South Penn. Oil	27,782	—	3,477	111	1.00	1.00
Southern Prod	8,579	98[4]	2,239	88	.50	.00
Standard Calif	603,468	110	109,343	105	1.50	1.50
Standard Ind	864,985	104	64,965	123	.70	62½[17]
Standard Jersey	3,071,000	110	344,000	117	2.50	2.15
Standard Ohio	177,175	112	10,173[3]	126	1.20	1.20
Sun Oil	323,663	98	24,407	120	.50	.50
Sunray Mid-Con	147,510	[8]	17,629	[8]	.60	[8]
Superior Oil	—	—	—	—	1.00	1.00
Texas Co	891,407	111	124,834[2]	128	1.50	1.50
Texas Gulf Prod	7,996	123	3,697	127	80[6]	.70
Texas Pacific	11,781	107	4,121	103	.70	.70
Tide Water Assoc	239,284	104	18,022	99	5%St.	.25+5%St.
Toklan Oil	—	—	—	—	.08	.07½
Union Oil of Calif	175,863	99	16,309	92	1.20	1.10
Union O. & G. of La.	11,530	117	616	71	.375	.35[5]
Universal Consolid	2,700	102	1,008	131	1.25	1.25
Warren Pet	—	—	—	—	1.00	.80
Wilcox Oil	4,230	78	430	139	.75	.50
Woodley Pet	1,958	128	485	126	.25	.25

[1] Adjusted after 3 for 1 stock split May, 1955.
[2] Including non-recurring net profit of $8,185,000.
[3] Including non-recurring net profit of $1,602,000.
[4] Excluding contract drilling gross income for 1954.
[5] Stock split April, 1955.
[6] Adjusted after 3 for 1 split June, 1955.
[7] Most earnings are non-recurring; realized from sale of Deep Rock assets to Kerr McGee.
[8] Before Sunray Mid-Continent merger.
[9] Adjusted for 2 for 1 stock split January, 1955.
[10] For 6 months ending March 31, 1955.
[11] Adjusted for 2 for 1 split April, 1955.
[12] Plus 1 share preferred for each 15 shares common.
[13] Including $14,160,571 from liquidation of American Republics.
[14] Adjusted for 2½ for 1 stock dividend early 1955. Stock dividend of 2% was paid December, 1954.
[15] Report for fiscal year ending April 30, 1955.
[16] Net income in 1954 was $51,905.
[17] Adjusted for 2 for 1 stock dividend December, 1954.



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* Patent applied for

Converting Meters to Feet and Feet to Meters

Meters to Feet:

Using 1 meter equals 3.281 ft
Top index gives units of 0.01, 0.1, 1, 10, 100, and 1000
Vertical index gives units of 1 through 10
Addition of component units gives answer
Typical solution:

Convert 1615 meters to feet

1000	meters	= 3281.0	ft
600	meters	= 1968.6	ft
10	meters	= 32.81	ft
5	meters	= 16.405	ft
1615	meters	= 5298.815	ft

Meters to Feet

	(0.01)	(0.01)	(1)	(10)	(100)	(1000)
1.	.03281	.3281	3.281	32.81	328.1	3281
2.	.06562	.6562	6.562	65.62	656.2	6562
3.	.09843	.9843	9.843	98.43	984.3	9843
4.	.13124	1.3124	13.124	131.24	1312.4	13124
5.	.16405	1.6405	16.405	164.05	1640.5	16405
6.	.19686	1.9686	19.686	196.86	1968.6	19686
7.	.22967	2.2967	22.967	229.67	2296.7	22967
8.	.26248	2.6248	26.248	262.48	2624.8	26248
9.	.29529	2.9529	29.529	295.29	2952.9	29529
10.	.32810	3.2810	32.810	328.10	3281.0	32810

Feet to Meters:

Using 1 ft equals .3048 meters
Top index gives units of 0.1, 1, 10, 100, and 1000
Vertical index gives units of 1 through 10
Addition of component units gives answer
Typical solution:

Convert 12,355 feet to meters.

10,000	ft	= 3048.0	meters
2,000	ft	= 609.6	meters
300	ft	= 91.44	meters
50	ft	= 15.24	meters
5	ft	= 1.524	meters
12,355	ft	= 3765.804	meters

Feet to Meters

	(0.1)	(1)	(10)	(100)	(1000)
1.	.03048	.3048	3.048	30.48	304.8
2.	.06096	.6096	6.096	60.96	609.6
3.	.09144	.9144	9.144	91.44	914.4
4.	.12192	1.2192	12.192	121.92	1219.2
5.	.15240	1.5240	15.240	152.40	1524.0
6.	.18288	1.8288	18.288	182.88	1828.8
7.	.21336	2.1336	21.336	213.36	2133.6
8.	.24384	2.4384	24.384	243.84	2438.4
9.	.27432	2.7432	27.432	274.32	2743.2
10.	.3048	3.048	30.48	304.8	3048.0

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Standard has built 4 catalytic reformers in the West to make these cleaner-burning, more powerful motor fuels required for best performance of today's higher compression engines. This program was two years in planning and building—cost $50 million.

This $50 million worth of plants is only part of the $350 million Standard is investing this year to make petroleum more useful and plentiful. Some of it will go for product research, part will pay for new manufacturing facilities. A good share will finance the search for new sources of oil to help supply the 733 gallons a year per person that go into thousands of oil-born products essential to modern living.

So the $350 million is an investment in your future as well as ours. It's one way Standard helps guarantee there'll be plenty of oil to do more jobs today and in the years to come.

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plans ahead to serve you better

DRILLING HYDRAULICS

Courtesy of Hughes Tool Company.

LINEAR VELOCITY OF DRILLING FLUID THROUGH THE ANNULUS

Curve shows the annular area between the drill pipe O.D. and the hole diameter plotted vs. rate of fluid circulation, with linear velocity of the drilling fluid through the annulus plotted as a parameter. The annular area for various hole sizes within the range 3⅞" to 15" for different drill pipe sizes is shown in a table.

On all drill stem designs except the external flush type, the annular velocity of the fluid between the tool joints and the well bore will be higher than that between the drill pipe and the well bore because of the tool joints having the larger O.D. These velocities will be the same in the case of external flush type drill stem where the tool joints and drill pipe both have the same O.D.

In any case, therefore, the velocity of the fluid between the drill pipe O.D. and the well bore will represent the minimum annular velocity throughout the circulating system.

If a definite linear return velocity through the annulus is desired, the rate of fluid circulation required can be determined as shown in the following example:

Given:
Hole diameter = 9⅞".
Drill pipe O.D. = 4½".
Annular velocity desired = 180 feet per minute.

Determine:
Rate of fluid circulation.

From Table:
Annular area in 9⅞" hole with 4½" pipe = 60.7 sq. in.

From Figure 15:
An annular velocity of 180 feet per minute through an area of 60.7 sq. in. will require 570 gallons per minute.

When the circulation rate is known, the linear velocity through the annulus can be determined as shown in the following example:

Given:
Hole diameter = 8¾".
Drill pipe O.D. = 4".
Rate of fluid circulation = 350 gallons per minute.

Determine:
Linear velocity through the annulus.

From Table:
Annular area in 8¾" hole with 4" pipe = 47.6 sq. in.

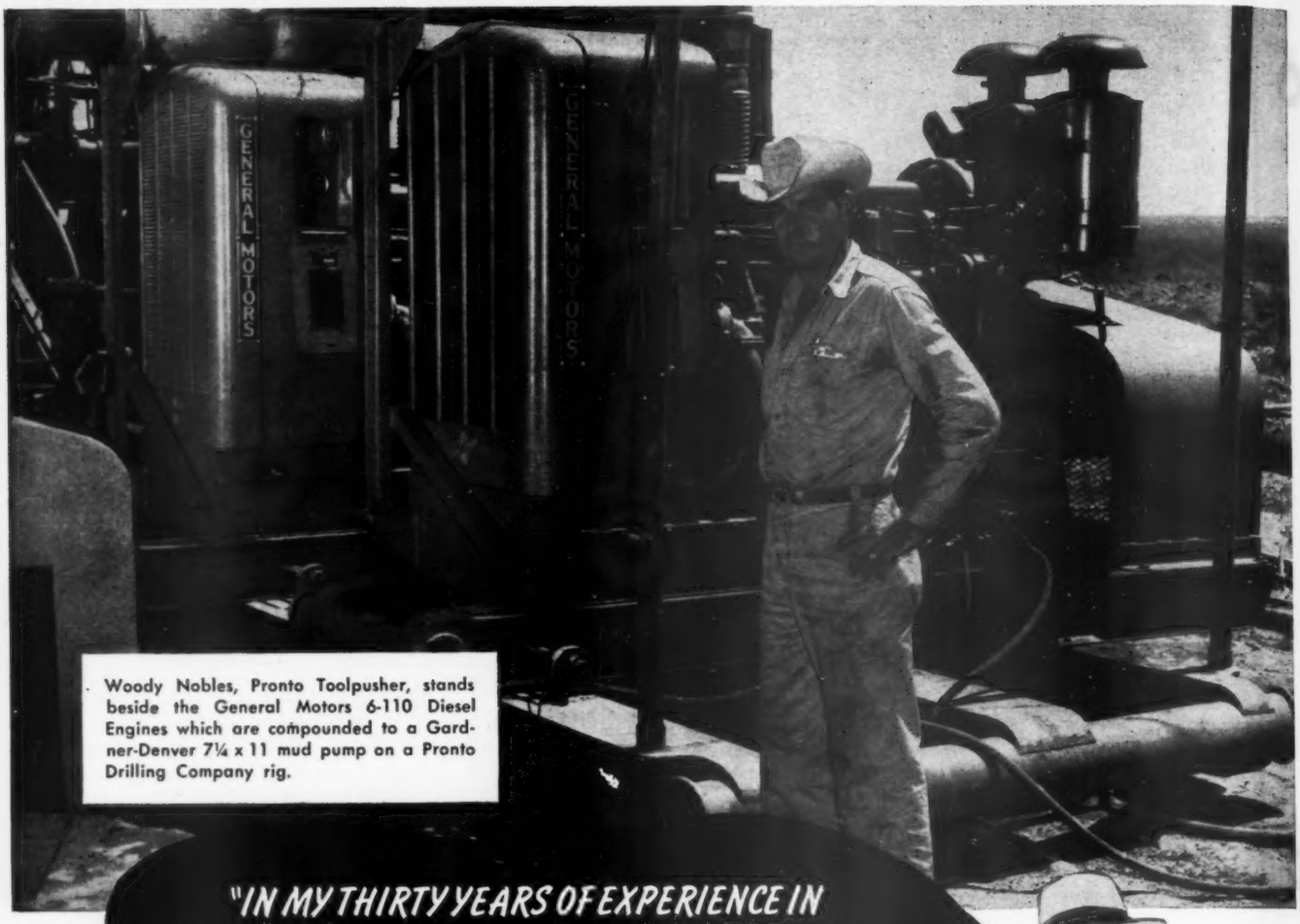
From Figure 15:
A circulation rate of 350 gallons per minute through an annular area of 47.6 sq. in. will produce a linear velocity of approximately 140 feet per minute.

NOTE:
Most holes are not the same diameter as drilled, therefore, the actual annular velocity obtained may differ from the calculated velocity.

ANNULAR AREA BETWEEN DRILL PIPE O. D. AND HOLE DIAMETER – SQUARE INCHES

Hole Diameter Inches	Drill Pipe Size (O.D.)—Inches							
	2⅜	2⅞	3½	4	4½	5	5½	6⅝
3⅞	7.4	5.3						
4¼	9.8	7.7	4.6					
4¾	13.3	11.2	8.1	5.2				
5⅝	20.4	18.4	15.2	12.3	9.0			
6	23.8	21.8	18.7	15.7	12.4	8.6		
6⅛	25.0	23.0	19.8	16.9	13.6	9.8	5.7	
6¼	26.3	24.2	21.1	18.1	14.8	11.1	6.9	
6¾	31.4	29.3	26.2	23.2	19.9	16.2	12.0	
7⅜	38.3	36.2	33.1	30.2	26.8	23.1	19.0	
7⅝	41.2	39.2	36.0	33.1	29.8	26.0	21.9	11.2
7⅞	44.3	42.2	39.1	36.1	32.8	29.1	25.0	14.2
8½		50.3	47.1	44.2	40.8	37.1	33.0	22.3
8⅝			48.8	45.9	42.5	38.8	34.7	24.0
8¾			50.5	47.6	44.2	40.5	36.4	25.7
9			54.0	51.1	47.7	44.0	39.9	29.2
9⅞			67.0	64.0	60.7	57.0	52.8	42.1
11				82.5	79.1	75.4	71.3	60.6
12					97.2	93.5	89.3	78.6
12¼					102.0	98.2	94.1	83.4
13¾					132.6	128.9	124.7	114.0
15					160.8	157.1	153.0	142.2

HERE'S ANOTHER REASON WHY STEWART & STEVENSON IS THE NATION'S LARGEST DISTRIBUTOR OF GM DIESEL ENGINES



Woody Nobles, Pronto Toolpusher, stands beside the General Motors 6-110 Diesel Engines which are compounded to a Gardner-Denver 7¼ x 11 mud pump on a Pronto Drilling Company rig.

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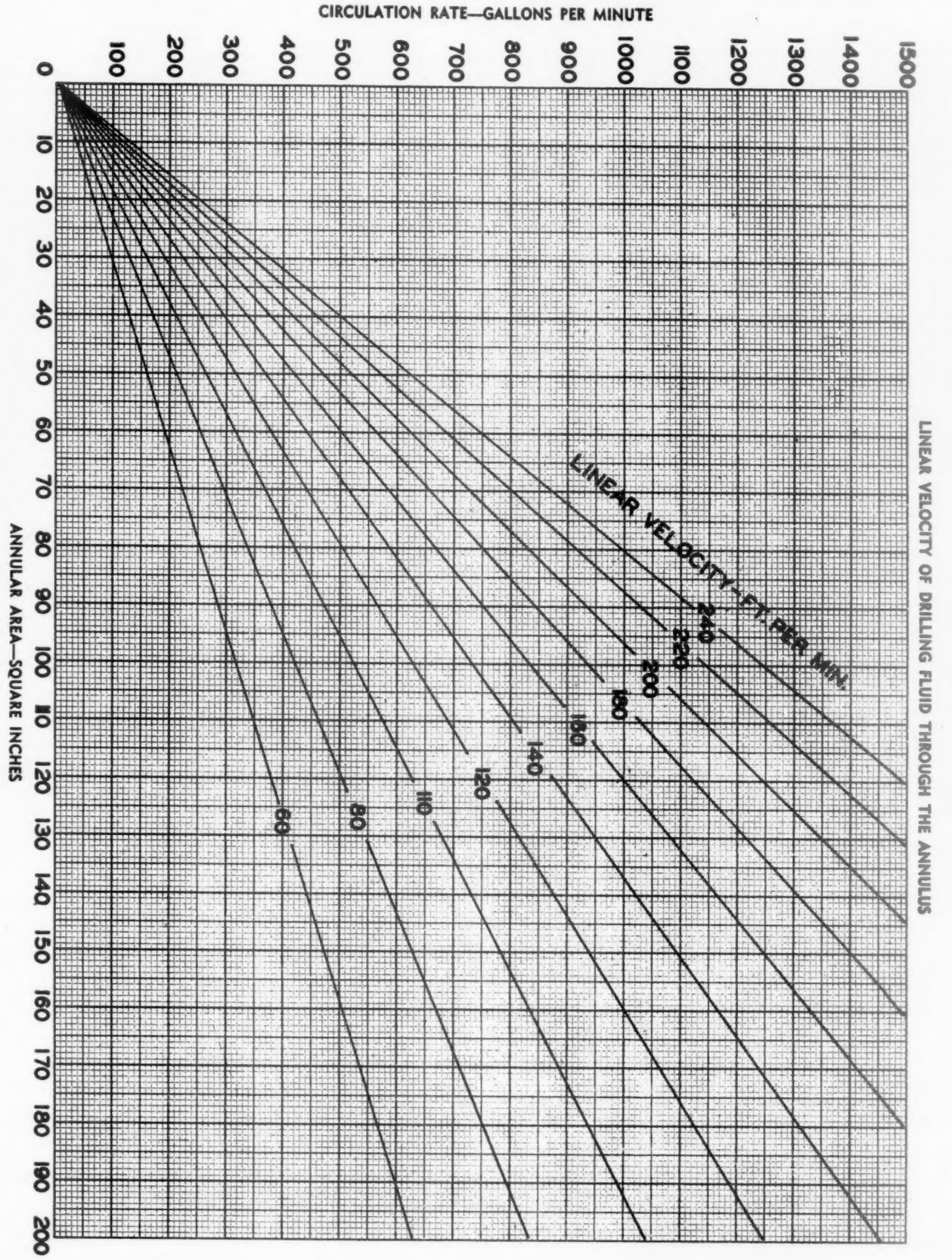
DRILLING HYDRAULICS



Courtesy of Hughes Tool Company

PERSONALS

Charles C. Rodd, zone superintendent of production for Gulf Oil Corporation, Wichita, Kansas, has been elected a vice president of the Fourth National Bank in Wichita. He will head the bank's newly formed petroleum department. A graduate of Missouri School of Mines, Rodd began work with Gulf in 1933. After World War II, he returned to Gulf serving in several executive-engineering capacities. In January of this year, Rodd was transferred to Wichita to serve as superintendent of production for the Kansas-Eastern-Rocky Mountain production zone. He terminates with Gulf Oil after twenty-two years of service.

C. C. Rodd

Frederick William Dittus, chief engineer of California Texas Oil Company, Ltd., since 1944, has been appointed an assistant vice president. A graduate of the University of California, Dittus has supervised construction projects in all parts of the world and is in charge of design and construction of refineries, pipe lines, and other major facilities for the Caltex group. He was first associated with Standard Oil Company of California in 1916. In Europe, from 1935 to 1937, he was in charge of procuring all construction materials for the Bahrain Refinery. **Robert R. Tillotson,** a veteran of 35 years with Caltex and Standard Oil of California, has been named managing director of Caltex Oil Refining (India), Ltd., which will operate the new Caltex refinery now under construction at Visakhapatnam, India. Tillotson joined SOCAL in 1920, became an analytical chemist, and then held positions of increasing responsibility at various SOCAL research laboratories and refineries. After going to Caltex in 1954, he spent several months in India getting first-hand knowledge of the area to which he has now been assigned. **Arthur Benson Brown** has become associated with Caltex as managing director, Caltex Pacific Petroleum Maatschappij, with headquarters in Djakarta. Brown is a former president of Richmond Oil Company, Lima, Peru. He was with Richmond for 25 years. **Robert Nelson Harding,** another newcomer to Caltex, has been made deputy managing director of CPPM and will serve with Brown in Djakarta. Harding transferred to Caltex from The Texas Company, with which for 18 years he was engaged in exploration work in the United States and Canada as a computer, surveyor, field operations executive and, finally, superintendent of the Northern Foothills Project in Calgary, Alberta, Canada.

The Canadian Petroleum Association has announced its staff of officers. They are **John W. Proctor,** general manager; **S. Douglas Turner,** Alberta division manager; **G. B. McGillivray,** Saskatchewan division manager; **John S. Peach,** director public relations; **T. J. McCubbin,** geophysical advisor and assistant director, public relations; **R. W. Diamond Jr.,** statistician, and **G. L. Humphreys,** secretary-treasurer.

E. L. Taylor

J. E. Stein

D. W. Conaway

D. W. Conaway has been appointed manager of the gas and gasoline section, production and engineering department, Dallas headquarters of The British-American Oil Producing Company. Conaway's position is a newly created one. He was transferred from the Denver, Colorado, office where he had been a district engineer. Conaway has been associated with British-American for five years, having joined the firm in Oklahoma City, Oklahoma. A native of West Virginia, he attended Fairmont State College, majoring in chemistry. He later attended West Virginia University, where he received his BS in mining engineering. **E. L. Taylor** has been made manager of outside operated properties section, another new section of the production and engineering department. Taylor joined British-American in 1949 in Tulsa, Oklahoma. Although born in Texas, his career in the oil industry began in 1928 in Oklahoma as a valuation engineer for an oil accounting firm. He received his BS degree in civil engineering from Oklahoma A&M College. Previously, he has held the positions of chief clerk and contracts supervisor in the production and engineering department. He will remain in the Dallas office in his new capacity. **John E. Stein** has been appointed district engineer for the northwestern district of British-American. During Stein's career with British-American, beginning in 1949, he has done engineering work in East Texas, Louisiana, Northern Oklahoma, Colorado-Nebraska and Wyoming. In his present capacity, he will continue to be headquartered in Denver, Colorado, where he has been a project engineer since 1954. Stein is a native of Rosate, Missouri, and received his BS degree in petroleum engineering from the Missouri School of Mines.

Lucien Hugh Cullen has been elected president of the recently formed Cullen Minerals Corporation, a uranium, oil, and gas firm, of San Antonio, Texas. He is a nephew of **Hugh Roy Cullen** of Houston, Texas. Lucien Cullen is the former president of Atomic Power Uranium Corporation and will remain a director of that organization. Other officers named are **W. R. Smith,** board chairman, vice president, and general counsel; **T. N. Tucker,** secretary and treasurer, and **W. Travis Sikes,** vice president, all of San Antonio. Also listed as directors are **John J. Cullen, W. E. Knickerbocker,** and **Max Rotholz,** all of Houston; **Terry A. Hornaday, H. J. Gravis, A. J. Kocurek, W. A. Jeffers,** and **N. A. Saigh,** all of San Antonio; **Pat Manford,** Smiley, Texas, and **William Pitzer, Jr.,** Midland, Texas.

Fred L. Mace, Denver, Colorado, assistant to Continental Oil Company's Rocky Mountain region general management, has been appointed assistant to the general manager of Egyptian-American Oil Company, a subsidiary of Conoco. **Harvey R. Peters,** Ponca City, Oklahoma, a member of Conoco's accounting staff, has been named accounting division supervisor for Egyptian-American. **Lindsey H. Edwards,** also of Ponca City, internal auditor for Conoco, has been made budget and fiscal supervisor for Egyptian-American. All three men will make their new headquarters at Cairo. Mace joined Conoco at Ponca City in 1948 and transferred to Denver the following year. He was successively chief production clerk and industrial relations manager for the company's Rocky Mountain region before his promotion in 1953 to assistant to the regional general management at Denver. Peters became associated with Conoco in 1947 and has held several positions in the company's accounting department at Ponca City for the past eight years. Edwards became associated with Conoco's accounting department at Ponca City in 1951 and then served two years with the company at Houston, Texas, before returning to Ponca City last year.

Dean A. McGee, president of Kerr-McGee Oil Industries, Inc., has been named as recipient of the distinguished service award of the Southern Association of Science and Industry, with presentation to be made later. The award is made annually to an industrialist.

J. G. Spratt, president of Trans Mountain Oil Pipe Line Company of Vancouver, British Columbia, Canada, has been appointed executive vice president and managing director of Triad Oil Company, Ltd. Spratt will continue temporarily as president of Trans Mountain until a successor has been appointed. Formerly president of Anglo-Canadian Oil Company, Spratt has spent his entire business career in the Western Canadian oil industry. In 1926, after receiving from the University of Manitoba a master's degree in geology, he was appointed to the department of the interior of the Canadian Government in Calgary as a geological assistant. Spratt became president of Trans Mountain in 1954.

Walter Davison, Tulsa, Oklahoma, has retired as assistant general counsel of The Carter Oil Company, with 39 years of industry legal practice behind him. Davison plans to travel. He has made many trips into Mexico and now plans a trip to Europe. He joined Carter in its title and lease department in Tulsa in 1916, after five months of law practice in Muskogee, after receiving his law degree from Ohio State University.

Returning to Carter in Tulsa after service in World War I, he helped develop some of the early principles of petroleum conservation. He later served as eastern division attorney for Carter. He returned to Tulsa and his position as assistant general counsel in 1946.

John H. Gray has resigned as director of public relations for Lion Oil Company. He will enter the Episcopal seminary at Austin, Texas, in September to prepare for the priesthood. Gray has been succeeded by **Kavanaugh W. Dodson, Jr.**

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DEATHS

William H. Atcheson, district manager of the Gulf Publishing Company of Houston, Texas, was killed recently when he accidentally ran into the propellor of an airliner at the municipal airport at Kansas City, Missouri. His home was in Tulsa, Oklahoma.

Shelby B. Goodman, who was a pioneer oil man and drilling contractor, recently died at his home in Shreveport, Louisiana.

Edgar M. Clark, a former director of Standard Oil Company of New Jersey, died recently at Phoenix, Arizona. He was co-inventor of the first successful petroleum cracking process.

John F. Canning died in Fort Worth, Texas, recently. He was president of Southwestern Petroleum Company.

John H. Collier, former president and chairman of the board of Crane Company, died recently at his home in Fairfield, Connecticut, after a long illness. He was president of Crane from 1941 to 1946 and served as chairman of the board from 1946 until 1951. Collier joined Crane Company in Chicago, Illinois, in 1903 after specializing in civil engineering at Purdue University, which in 1942 awarded him the degree of Master of Industry.

Tom C. Craig, head of Phillips Petroleum Company's natural gas division in the Texas Panhandle, died recently in Amarillo, Texas. He had suffered a cerebral hemorrhage at his office.

John Francis (Frank) Cullinan of Houston, Texas, retired vice president of American Republics Oil Company, died recently in a hospital at Alexandria, Minnesota, after a short illness. He had been staying at his summer home in Alexandria. Born in Pennsylvania, Cullinan went to Corsicana, Texas, where he was an official of the Producers Oil Company, the company that later consolidated with The Texas Company when it was organized by his brother, the late **J. S. Cullinan.** Frank Cullinan retired two years ago as vice president of American Republics, an oil firm he and his brother founded in 1915 and which was sold to Sinclair Oil & Gas Company earlier this year.

Dr. William J. Hale, chemist and research scientist for The Dow Chemical Company, died recently in Midland, Michigan, after a short illness. A native of Ada, Ohio, Dr. Hale earned degrees from Miami University (Ohio) and Harvard University, where he received his PhD degree. Later, Miami awarded him an LLD degree. He was a member of Phi Beta Kappa. From 1904 until in 1917 when he joined Dow, Dr. Hale taught at the University of Michigan. Dr. Hale was the father of the science of chemurgy, the name of which he coined from two Greek words meaning "chemistry at work."

King Gaines Gillette, former president of Golden West Petroleum Company and son of the late razor manufacturer, died recently at his home in Newport Beach, California.

George William Lucas, supervisor of carbide materials and process engineering, Carboloy department of General Electric Company, and a pioneer in the development of cemented carbide metals in the United States, died recently. Lucas, who joined the Carboloy organization 27 years ago, was one of a handful of men who formed the organization in Cleveland, Ohio, when it was known as Carboloy Company, Inc. A research scientist who came up the hard way, he was responsible for the development, through the process of powder metallurgy, of the first standard grades of cemented carbides to be commercialized in the United States.

Alfred Rupp, colorful exploration pioneer in the West, died recently at Morro Bay, California. Rupp was instrumental in getting a new oil production era started in California in the early 1900's. For years, he was prominent in exploration and drilling on the West Coast and in Mexico and Central America.

Joseph N. Dwight, who was a veteran of the oil field supply industry, died recently from pneumonia in Guthrie, Oklahoma. He retired in 1929 after 23 years as head of the production equipment department of Lucey Products Corporation.

Robert George Cole, sales manager of Orbit Valve Company, died recently at his home in Tulsa, Oklahoma, from a heart attack. A native of Lewiston, Montana, he joined Orbit Valve in 1941. Cole became sales manager of the company in 1951.

Bernard W. (Marc) Anthony, secretary and treasurer of Oronite Chemical Company, died recently at Lafayette, California, of a heart attack.

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A THOMPSON Separator Is Necessary Equipment —

The consistent, dependable action of a THOMPSON Vibrating Shale Separator removes troublesome shale and abrasives from drilling mud ... vitally necessary for the job to be done in a way to prolong life of drilling tools, eliminating necessity of replacing expensive drilling muds, and keeping re-tooling at minimum.

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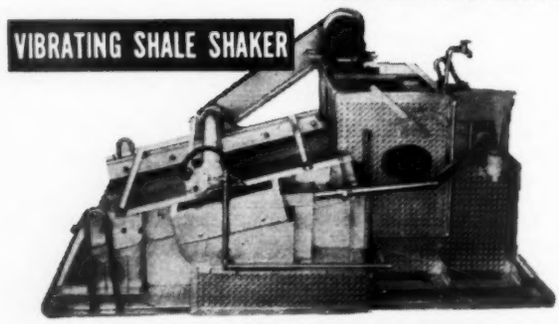

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BOOKS ★

Biennial Report 1953 and 1954; National Bureau of Standards, *National Bureau of Standards Miscellaneous Publication 213. Pages, 162. Price, 60 cents. (Order from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.).*

This report summarizes the research and development activities of the National Bureau of Standards in the physical sciences during the fiscal years 1953 and 1954. Brief descriptions are given of representative accomplishments in each area of the Bureau's responsibilities, which include maintenance of basic standards, determination of physical constants and properties of matter, development of methods and instruments of measurement, and the provision of calibration, testing, and scientific advisory services.

During the two years, significant results were achieved in programs dealing with electronic computers, electronic instrumentation, and the properties of matter and materials. A new high-speed computer—DYSEAC—which controls and responds to a variety of external devices, was completed and delivered to the Department of Defense. Low-temperature alignment of radioactive nuclei provided new aproaches to the study of nuclear disintegration processes.

The biennial report is composed of five sections: (1) A general review or summary, (2) a resume of the Bureau's research and development work in progress or completed during the 1953 and 1954 periods, (3) a review of the testing and calibration program, (4) a discussion of the Bureau's various cooperative activities, and (5) an appendix consisting primarily of statistical and organizational material and a complete list of publications by NBS staff members for the two fiscal years.

Principles of Emulsion Technology, *by Paul Becher, published by Reihold Publishing Corporation, 403 Park Avenue, New York 22, New York. Pages, 150. Price, $2.95.*

This book is the fifth in the Reinhold Pilot series of technical, pocket-size, cloth-bound guide books. It was written for those who have studied chemistry and want to know more about both theoretical and applied emulsions than is given in most physical chemistry courses.

Materials and Equipment for the Petroleum Industry, *Compiled by the Association of French Manufacturers of Equipment, published by La Revue Francaise de l'Energie, 3 rue Soufflot, Paris 5, France. Pages, 480. Price, $7.00.*

The Association of French Manufacturers of Equipment for the Petroleum industry has assembled the products and services of 225 suppliers and contractors whose activity has proved to be satisfactory to oil industrialists in France and elsewhere.

This book is the first issue of their official catalog which is intended to describe the materials and equipment which the members of the association are able to supply to the petroleum industry. The entries have been established so as to inform the reader of the present technical descriptions of materials available from the manufacturers, specifications, data, etc. A special section shows an alphabetic index of the members of the association, a classified list of materials (with English translations) with reference to the fabricators concerned, a repertory of patents, licenses and trade marks, an English-French lexicon of the most usual technical words utilized in the oil industry, and a series of conversion tables of American, British and metric units.

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OIL and GAS TRADE NEWS

Schlumberger Expands in Illinois

Schlumberger Well Surveying Corporation has opened a new location at Harrisburg, Illinois, to take care of increased activity in the southern end of the Illinois Basin due to the recent discovery of the Eldorado field. Willis P. Baker is in charge of the new station. Joseph A. McGuire is engineer. Both logging and gun perforating services will be available from Harrisburg.

Wolverine Sales Office Moved

North California sales offices of Wolverine Tube, division of Calumet & Hecla, Inc., have been moved to San Francisco at 1301 Sixth Street, Room T. Appointment of R. C. Cain as a new sales representative has also been announced.

Wire Line Truck Has New Features

A new wire line truck designed and assembled by Camco, Inc., Houston, Texas, provides in compact space every necessary feature for efficient and accurate wire line operation. The unit is mounted on a Ford panel truck, complete with hydraulic reel, electronic weight indicator, and sound device. This unit is powered by two Denison hydraulic motors connected so that full torque is delivered with both motors or half the torque and twice the speed when only one motor is operating. Unit will come out of the hole from 12,000 ft at a speed of 1200 ft per minute and will deliver a line pull at the surface of 1600 lb at maximum torque. One of the improvements of this unit is an electronic weight indicator, manufactured by Bowen Company of Texas, which measures the load line in pounds. Also a sonic device, manufactured by Associated Equipment, reflects the down-hole noise to a speaker in the truck. A built-in testing device, complete with nitrogen bottle, tests gas-lift valves at the well as they are brought to the surface. The new truck offers power, control, and versatility in wire line operations.

Chief feature of IBM's new Data Processing Center at the company's New York City headquarters is the 702 Electronic Data Processing Machine shown here, with an operator giving instructions to this "giant brain." On view in the background are eight magnetic-tape units through which information is fed to and delivered from the machine.

Team of 'Giant Brains'

International Business Machines Corporation recently demonstrated to the press its new electronic data processing center at the company's headquarters in New York City. More than 25 presidents of leading railroads and groups of executives from other industries have been invited as guests at the center to see the equipment demonstrated.

The center contains an intergrated team of so-called "giant brains," a complete line-up of high-speed digital computers and data processing equipment. Included are the IBM 702, 701, and 650 electronic data processing machines as well as smaller, medium-sized electronic calculators.

This versatile combination of machines makes available on an hourly charge basis the latest tools for scientific management to companies that do not need full-time data processing facilities of such capacity and speed and to companies whose own facilities are overloaded.

An oustanding feature of the press showing was a series of demonstrations on the three largest machines.

The center can handle all types of data processing work for business and scientific work.

In order to provide in compact space every necessary feature for efficient and accurate wire line operation, a new wire line truck has been designed and assembled by Camco, Inc. The unit is mounted on a panel truck as seen in photograph.

Mobile Power Plant Shown

An unprecedented type of electric power plant mounted on two railway cars was run through its paces recently in Seattle, Washington, for officials of the U. S. Army Corps of Engineers by Westinghouse Electric Corporation. The power plant, built by Westinghouse, was assembled at the Puget Sound Bridge and Dredging Company, which built the railway cars. A week-long series of tests preceded its delivery to the army. The 5000-kw gas turbine, railroad-mounted power plant was built for use in devastated areas, and its components are arranged on two 54-ft long railway cars. This new mobile unit is adapted not only for standard American gage of 56½ in. but also 69,-63, and 66 in. for foreign railways. One such unit could easily satisfy the electric power requirements of the average industrial plant. Several operated in parallel could produce power adequate to operate even the largest industrial plant. Westinghouse built railway-mounted power plants using steam turbines during World War II. These units also were rated at 5000 kw, but they required eight cars for housing.

Vermette Power Drive Acquired

The Toledo Pipe Threading Machine Company has announced a new addition to its line of pipe tools and machines, the Toledo No. 78 Vermette power drive, which is already well-known in the industry under the Vermette name. This power drive features extra-heavy duty construction combined with compactness and light weight. The complete unit with folding tripod legs weighs only 75 lb, and it can be carried and operated by one man.

1105...YES, ELEVEN-O-FIVE

Is the new-strength wire in Roebling's

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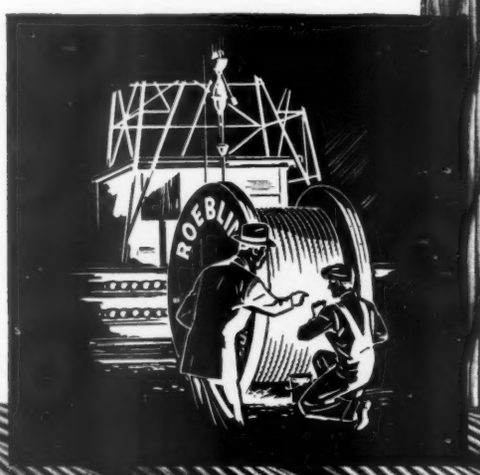
WIRE 1105 ROPE

AS SIZES and constructions go, Royal Blue is like the ropes you have used until now... but the likeness ends there.

Royal Blue is made of Roebling's new 1105 wire, the strongest, toughest wire developed up to now for use in any wire rope.

Royal Blue Wire Rope is as enduring as the wire from which it is made.

Write us for full facts on Royal Blue Wire Rope, or contact your Roebling distributor.



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SMOOTH TRAILING, easily spotted at job site, Kwik-Mix 6-S Dandie does on-the-spot mixing for concrete slabs, footings, and other widely-scattered jobs at drill sites, booster stations, around yards, refineries. Here are some of the operating advantages you get for one-man mixing and pouring:

SELECTIVE SKIP SHAKER engages automatically — speeds flow of aggregates and cement into the drum, can be set for shaking when skip is full, or partially empty. It is readily disengaged when no shaking action is needed.

AUTOMATIC WATER SYSTEM is accurate within a fraction of a pint. Valve opens automatically as skip is raised — water enters drum with aggregates at proper time to eliminate clogging. Folding action of blade-and-bucket drum double-mixes every batch.

TILTED FLOW-LINE DISCHARGE CHUTE with easy toggle-lever control reaches far into drum, catches all concrete — pours complete batch in 7 seconds.

MULTIPLE V-BELT DRIVE, high-carbon steel drum with double-thick roller paths, reduction gears enclosed in oil, and antifriction bearings throughout all assure dependable, trouble-free performance with this Kwik-Mix heavy-duty 6-S mixer.

OPTIONAL 6-S EQUIPMENT: distribution spout, auxiliary hoist, water pump, Batchmeter. Other sizes: 3½-S to 16-S Dandie concrete mixers. Also: 10 and 15 cu. ft. Moto-Bugs® with hopper, platform, fork lift attachments. See Kwik-Mix distributor, or write.

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Amazing NEW Oakite

RUSTRIPPER

...Slashes tower down-time by more than 25%!

Texas refinery saves $1200 in ONE Cleaning Operation

Refiners everywhere are finding more and more uses for revolutionary Oakite RUSTRIPPER. This remarkable NEW alkaline material simplifies practically every cleaning job...reduces costs, too. Here's how amazing Oakite RUSTRIPPER saved one Texas refiner $1200 in a *single* cleaning operation:

The problem was to recondition a 28-tray, 5 man-way oil absorber tower containing 2304 four-inch bubble caps. Last cleaning had taken 24 hours—an extremely expensive proposition, since every hour of down-time costs this refinery $100! The superintendent agreed to give Oakite RUSTRIPPER a try.

After rinsing the tower with steam and hot water for two hours, a pre-mixed solution of Oakite RUSTRIPPER was pumped into the unit from a 1000-gallon tank mounted on skids nearby. The solution was recirculated and agitated for ten hours at 210°, then routed through the mist extracter for an additional three hours, and drained out. A three-hour circulating water rinse completed the cleaning cycle.

Results? Oakite RUSTRIPPER had not only accomplished a cleaning job that was 95% perfect, but had reduced down-time by *six* hours, slashed cleaning costs by *$1200!*

Oakite RUSTRIPPER is also excellent for reconditioning salvaged parts, stripping paint from metal equipment, and many other heavy-duty refinery conditioning chores. RUSTRIPPER is safe, too...won't attack sound metal or give off troublesome fumes. Your local Oakite Technical Service Representative will gladly demonstrate remarkable Oakite RUSTRIPPER for you at your convenience. Call him today...no obligation. Or write Oakite Products,

SPECIALIZED INDUSTRIAL CLEANING

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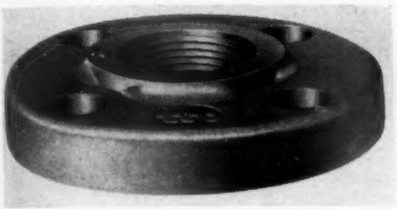
MATERIALS • METHODS • SERVICE

Technical Service Representatives in Principal Cities of U. S. and Canada

Solvent Welding PVC Pipe Fittings Introduced

Maintenance Engineering Corporation, Houston, Texas, is introducing a complete line of solvent welding pipe fittings and flanges of injected molded unplasticized polyvinyl chlorides produced by Tube Turns Plastics, Inc., Louisville. They are the first to be produced on a commercial scale by the injection molding process.

According to C. E. Naylor, chairman of the board of directors of Maintenance Engineering, solvent weldings permit fast, easy installations to be made with a minimum of tools and equipment. Naylor pointed out that since the connecting surfaces of both the fitting and the pipe are smooth, there is no notch effect. PVC piping systems fabricated with Tube Turns Plactics' solvent welding fittings are recommended where installations are of a permanent nature. The threaded type is recommended where disassembly, revamping, or revising of the systems may be required.



The solvent welding fittings are in addition to Tube Turns Plactics' complete line of threaded fittings, now being widely used in PVC piping systems in the chemical, food, drug, petroleum, paper, textile, and other industries where corrosion is a serious problem. Both lines now include 90-deg and 45-deg elbows, tees, unions, couplings, caps, reducing bushings, and flanges.

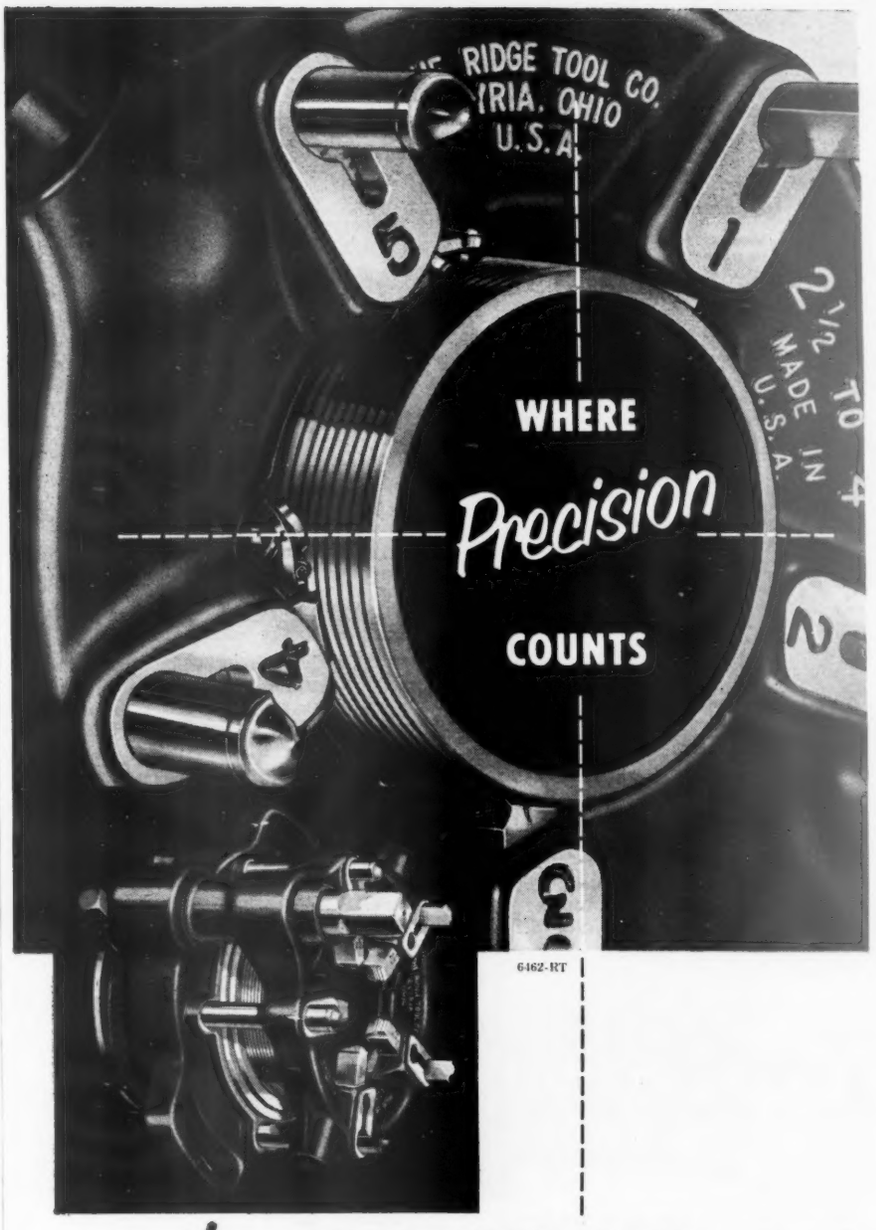
The high density and homogeniety of products made by Tube Turns Plastics, Inc., are largely due to the exclusive Hendry Process employed by the company.

Textron Purchases Homelite

Textron American, Inc., has announced the recent purchase of the Homelite Corporation of Port Chester, New York, manufacturers of chain saws, generators, blowers, and pumps. Homelite's current sales of chain saws, pumps, and generators are running at the rate of $20,000,000 per year. New models scheduled for introduction in the near future include a lightweight, low-cost generator, a diaphragm pump, and several new chain saws. With these new models, Homelite Corporation has set a goal of $30,000,000 for annual sales within the next few years. Officers of the company are: J. A. Abbott, president; Nelson Thompson, vice president-sales; R. C. McDonald, vice president-manufacturing; A. K. Newman, vice president-engineering; DeHaven Ross, secretary and treasurer, and Rita Powers, assistant secretary. Homelite Corporation will be an independently operated subsidiary of Textron American, Inc., without change in management, personnel, or policy.

Tubeseal Non-Exclusive Licenses

The Hammond Iron Works has announced that its Tubeseal system for floating-roof tanks is now offered to fabricators of floating-roof tanks. Licenses will be issued on a non-exclusive basis.



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2½" TO 4" GEARED PIPE THREADER

Here's a work-saving precision tool that cuts accurate threads on 2½" to 4" pipe *every time.* It's easy to handle . . . easy to use . . . foolproof.

Operated manually or with power, the RIDGID 4P reduces time, sweat and scrap in any piping job. Balanced handles simplify carrying and starting on pipe. Mistake-proof workholder sets to size *before* tool is put on pipe . . . has only one screw to tighten . . . no bushings.

For precision and speed . . . you can't beat the RIDGID *4P!*

See your local supplier . . . or write direct for catalog.

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WORK-SAVER PIPE TOOLS

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Mrs. J. A. Cleverley, wife of the vice president of Cities Service Oil Company, prepares to christen the $1,500,000 drilling tender "Jack Cleverley" named in her husband's honor. This is the fourth in a series of such drilling tenders constructed by the Levingston Shipbuilding Company at Orange, Texas, for the CATC Group, composed of Continental, Atlantic, Tide Water, and Cities Service.

CACT Drilling Tender Christened

The drilling tender "Jack Cleverley" was christened at the builder's yard, Levingston Shipbuilding Company, in June. Sponsor was Mrs. J. A. Cleverley, wife of the vice president of Cities Service Oil Company, in whose honor the vessel was named.

The "Jack Cleverley" is the fourth in a series of $1,500,000 drilling tenders constructed by Levingston for a joint offshore venture known as the CATC Group. Members of the CATC Group, each with a 25 per cent interest, are Continental Oil Company, Atlantic Refining Company, Tide Water Associated Oil Company, and Cities Service Oil Company, with Conoco being the operator for the group.

This latest drilling tender is a floating, non-self propelled type vessel similar to the three previous tenders. First tender was the "J. C. Craig," named in honor of the production superintendent of Continental Oil Company, marine division, and was the first of its type to be built in Texas. Second was the "Carle Sharp," named after the manager of the domestic producing department, Gulf Coast region of the Atlantic Refining Company, and third was the "Ernie Miller," named in honor of the vice president and general manager of Tide Water Associated Oil Company.

These vessels were tailor-made for CATC operations and built to class under the rigid inspection of the American Bureau of Shipping, United States Coast Guard, and to conform with the requirements of the United States Public Health Service.

Four Billionth Tetraethyl Pound

Ethyl Corporation reached a major milestone at Baton Rouge, Louisiana, recently with the shipment of the four billionth pound of tetraethyl lead, principal ingredient of "Ethyl" antiknock compound. The four billionth pound was contained in a tank car of Motor Plus dispatched to a West Coast refinery. Motor Plus is the improved "Ethyl" antiknock compound for motor gasoline, introduced late in May, which acts to curb the increase in gasoline octane requirements of automobiles by reducing engine deposits.

Partridge Wins Hecht Award

Dr. Everett P. Partridge, director of Hall Laboratories, Inc., has been presented the 1955 Max Hecht Award of the American Society for Testing Materials in recognition of his 30 years of contributions to the technology of industrial water. At the ASTM's recent annual convention in Atlantic City, the director of the Pittsburgh, Pennsylvania, water consulting and engineering firm was cited for his writings and discussions on a number of technical subjects in his field. The Hecht Award, which goes annually to a member of ASTM Committee D-19 on industrial water, also mentioned Dr. Partridge's activities on technical committees. For some 13 years, he was standards editor of the ASTM water engineering group. He is head of the group that recently completed for the American Society of Mechanical Engineers a revised code on the suggested chemical care of power boilers. He is a past chairman of the joint research committee on boiler feedwater studies. Most recently, Dr. Partridge has been active as a member of the high purity water committee of the National Association of Corrosion Engineers and the intersociety corrosion committee, according to the citation.

Houghton Expands Research

Houghton Laboratories, Inc., has announced an expansion program for the firm's research department. A new research building, incorporating many features, will double the floor space and capacity of the former quarters. Modern equipment being installed in the new research center will provide the company with the complete facilities for plastic research.

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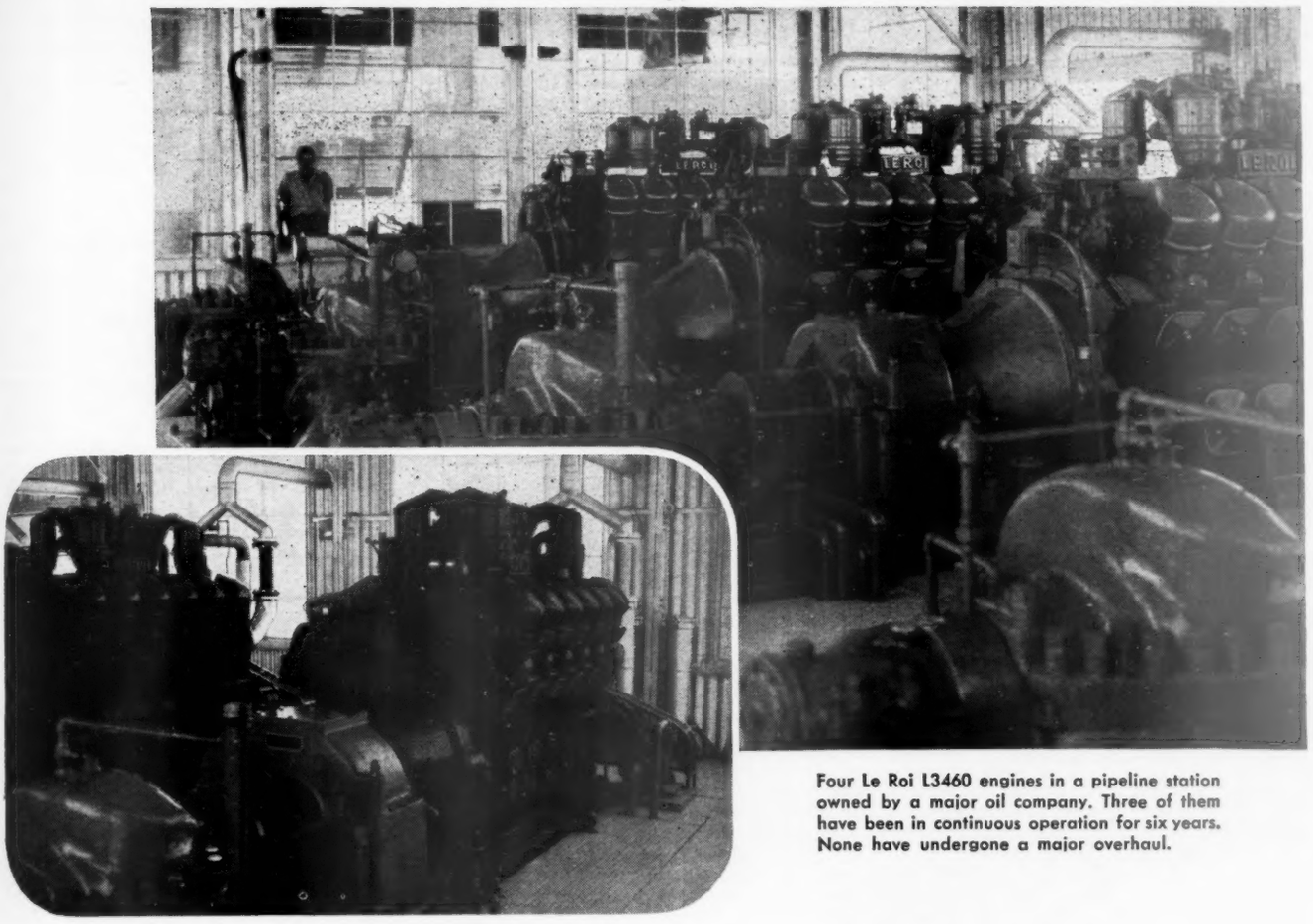

Four Le Roi L3460 engines in a pipeline station owned by a major oil company. Three of them have been in continuous operation for six years. None have undergone a major overhaul.

Power-Packed Pipeline Station

. . . uses Le Roi L3460's to provide plenty of low-cost pumping power

Le Roi's L3460 with 600 max. hp. and its bigger brother, the L4000 with 655 max. hp., are ideal for pipeline service on many counts. Here's why:

Plenty of power with good fuel economy—These engines develop 600 and 655 max. hp. with rock-bottom fuel consumption, and can be run on natural gas, gasoline, or butane. Advanced design manifolding, low friction bearings, and low power loss to accessories, all contribute to unusual operating economy.

Long engine life—Perhaps the best proof of this statement is found in the trouble-free performance experienced by users in installations like the one shown above. Basically the L3460 and L4000 are compact, high-output engines designed with short stroke to give you greater horsepower and speed, without compromising engine life. And that's exactly what they do for you.

More comfortable operating conditions—Water-cooled exhaust manifold cuts down engine heat in operating areas, yet provides fast engine warm-up. The smooth, clean lines of these engines prevent dirt from collecting—that's why they are so easy to keep clean.

Compact V-12 design packs a lot of horsepower in a small space—to give you more horsepower per dollar. This, plus vibrationless performance, reduces foundation costs, simplifies installation.

We think that if you see an L3460 or L4000 in operation you'll agree that they provide the answer to low-cost pumping power. Have your supply house or Le Roi distributor show you one at work. Bulletins are available upon request—just write us.

P-140

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STATIONARY AIR COMPRESSORS

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ENGINES

Trade News

Kellogg Begins Ammonia Plant

The M. W. Kellogg Company, has announced that it has begun initial activities in the construction of a 300-ton per day anhydrous ammonia plant for The Standard Oil Company of California's new multi-million dollar petrochemical facilities at Richmond, California. A substantial proportion of the daily production of this new plant will be used in the manufacture of complete fertilizers.

TP&L Wins Award

Texas Power & Light Company was named winner of the electric industry's highest honor, the Charles A. Coffin Award for 1954, in ceremonies conducted at the 23rd annual convention of the Edison Electric Institute in Los Angeles California. The award was presented to W. W. Lynch, TP&L president, by Phillip D. Reed, chairman of General Electric Company, donor. This award is presented annually to the electric utlity company judged as making the greatest contribution to the advance of the industry and service to customers. TP&L is the first company in the Southwest to win this award, which was established by the General Electric Company 33 years ago in honor of its first president.

First Pipe to Pacific Northwest

The first pipe to be shipped to the Pacific Northwest Pipe Line right of way and the first shipment of pipe to move from U. S. Steel's newest western installation, the Provo, Utah, pipe mill of the Consolidated Western Steel division, began recently. Pipe was shipped on a 100-carload train carrying 1700 sections of the 26-in. diameter pipe to the Colorado site of installation crews.

Dow Educational Grants

Gifts totaling more than $300,000 for educational grants to colleges and universities in the U. S. for the advancement of science and engineering have been announced by The Dow Chemical Company for 1955-56. A major phase of the aid-to-education program is the authorization of $133,500 for distribution to 38 colleges and universities for the establishment of graduate fellowships and undergraduate scholarships and to two educational foundations for use in assisting deserving students. Another part consists of $167,500 allocated to 19 institutions, most of it earmarked for their unrestricted use in current expansion and operating programs. Over and above these grants, the company has allocated $140,000 for distribution to a number of schools for research on specific projects.

Diesel Mechanics Outside U. S.

Another step toward making on-the-job training in the proper operation and servicing of General Motors diesel engines available throughout the world was taken in June when the Detroit service department of General Motors Overseas Operations took delivery on a mobile training unit for its branch in Caracas, Venezuela. Delivery was taken at the Detroit Diesel Engine division factory in Detroit, Michigan, and the unit is similar to those used throughout the United States in Detroit Diesel's own training program. The new unit will operate throughout Venezuela, bringing factory-approved preventive maintenance and overhaul procedures to hundreds of Diesel operators and mechanics in the oil well drilling, construction, agricultural and marine fields.

Hammel-Dahl Names Representative

Hammel-Dahl Company of Providence, Rhode Island, has appointed the Russell F. Clark Company, Pittsburgh, Pennsylvania, as their new sales and service representatives for western Pennsylvania and part of West Virginia.

Automatic Logger Contract

Fischer & Porter Co., Hatboro, Pennsylvania, has contracted to build a large industrial data reduction system for the new Canadian Petrofina, Ltd., refinery soon to go into operation in Montreal, Canada. The planned Automatic Logger, a $50,000 installation, will automatically monitor, analyze, and record a total of 480 process variables for all nine production units at the Canadian refinery.

In terms of scope of operation, the Automatic Logger is designed to eliminate routine checking by control personnel and guarantee accurate records even during times of refinery upsets. The Automatic Logger is scheduled to tie into the 20,000 bbl per day refinery in November.

Lane-Wells Students Making Progress

"Excellent" reports have been received from five schools and universities on students who are studying petroleum engineering on Lane-Wells scholarships. Students include Donald B. Bonnecarrere, Louisiana State University; Richard G. Brandom, University of Oklahoma; Ralph F. Cox, Texas A&M; Michael Sanchez-Navarro, University of Texas, and Charles A. Schuh, Pennsylvania State College.

MURPHY Safety Switches Are *Automatic*

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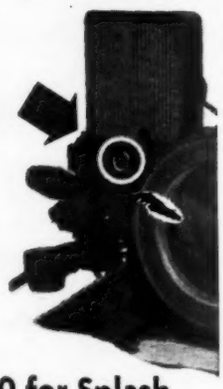

Stops Engine Automatically When Fan Belt Breaks or Water Level Falls Too Low.

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Westinghouse Class Largest

Largest class in the four-year history of the Westinghouse-Johns Hopkins Awards leading to careers in engineering was announced with the naming of 36 high school graduates as winners in the 1955 competition. The three-year program of part-time employment in industry combined with actual classroom study at the Johns Hopkins University's McCoy College leads to a certificate of engineering for participants. It is considered to be the only scholastic program of its kind.

Magnetic Industries Item on TV

Magnetic Industries, Inc., of Houston, Texas, has developed an electronic valve-regulator for maintenance of proper flow from well into pumping stations. A demonstration of the device was shown through the TV program "Industry on Parade."

Magnetic Industries worked with another Houston firm, the McEvoy Company, to film the demonstration.

B-L-H Makes Appointments

Baldwin-Lima-Hamilton Corporation, construction equipment division, Lima, Ohio, has made two distributor appointments. Hawkeye Machinery Company, Inc., Des Moines., Iowa, has been named distributor of Lima shovels, cranes, draglines, pull shovels and Austin-Western crushing equipment, covering the central and eastern portions of the State of Iowa. Bert Smith Road Machinery Company, Inc., Enid, Oklahoma, has also been assigned the Lima line, covering the State of Oklahoma with the exception of six extreme eastern counties.

Tube-Kote Expands

Greatly expanded facilities for coating oil field pipe and other equipment with KT-2 plastic have been made known by Tube-Kote, Inc., of Houston, Texas. The company has recently acquired a new bake oven, specially designed automatic spraying units, and allied equipment. Over-all expansion in recent months has more than doubled plastic-lining capacity of the 15-acre plant.

Daniel Orifice Opens New Plant

Meeting the need to step-up production to supply increasing demands from the industry, the Daniel Orifice Fitting Company recently completed and formally opened its new facility in Houston, Texas. This site covers 15 acres. Sales and executives offices are housed in a modern office building that takes up 6000 sq ft of space. The new fabricating shop has more than 10 000 sq ft, and the machine shop covers 5000 sq ft. Complete warehousing facilities use 5000 additional square feet of space. W. A. Griffin is vice president and general manager in charge.

Worthington Moves Chicago Office

Worthington Corporation's Midwest regional engineering and service division, Chicago, Illinois, formerly located at 400 West Madison Street, has been moved to new and air conditioned quarters at 6124 North Pulaski Road, Chicago. This expanded operation will be under the direction of L. R. Dise, manager. A new and extensive stock of air conditioning and refrigeration parts and mechanical transmission products will be added to better serve Worthington's air conditioning, refrigeration, power transmission, and industrial customers. The Chicago district sales office, with W. C. Cheek as manager, will continue at the Madison Street address.

Dow Field Offices Created

Elevation of The Dow Chemical Company's Minneapolis, Minnesota, and Cincinnati, Ohio, field offices to full sales office rank and plans for opening a new sales office in Buffalo, New York, have been announced. Marion E. (Roy) Teller has been advanced to manager of the Minneapolis office, Edward C. Earley to manager of the Cincinnati office and Eugene L. Martinez to manager of the Buffalo office, which is expected to open late this year. The Minneapolis office was established in 1953 as a branch of the Chicago office, and the Cincinnati office opened a year ago as a branch of the Cleveland office.

Pritchard Names Representative

Factory Sales and Engineering, Inc., of New Orleans, Louisiana, has been appointed sales representative for the Southern half of Louisiana and the Southern two-thirds of Mississippi by J. F. Pritchard and Company of California, Kansas City, Missouri.

Sharples Now Pennsalt Division

Sharples Chemicals, Inc., has been dissolved as a corporation and has become an operating division of the Pennsylvania Salt Manufacturing Company. Sharples was acquired by Pennsalt Chemicals through an exchange of stock in 1951. Its operations will continue without change under the direction of Lee H. Clark, general manager.

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TRADE PERSONALS

▸ **Alvin J. Fink** has been appointed an assistant regional manager in charge of industrial sales operations for Taylor Instrument Companies. His region includes Los Angeles, California, and the Intermountain territory.

▸ **Don W. Lyon** has been appointed manager of textile sales of the L. O. F. Glass Fibers Company. He will headquarter at the general offices in Toledo, Ohio.

▸ **Edwin L. McCarty** has been appointed manager of the Kansas City, Missouri, territory for Morse Chain Company, a Borg-Warner industry. McCarty replaces **C. B. Lane,** who has been transferred to the firm's Houston, Texas, office.

▸ Three men have been appointed to key executive positions by The Polymer Corporation. **Conrad H. Busch** has been named to the newly created position of advertising manager; **Robert B. Zimmerli** has been appointed sales manager of the firm's subsidiary, National Polymer Products, Inc., and **Kenneth G. Harms** has been assigned as technical service manager of the parent company.

▸ A two months' program of promotions and transfers has just been completed by Hughes Tool Company. The following new assignments have been made: **E. M. Connor,** regional manager western division, Midland, Texas; **R. E. Kimsey,** western regional sales consultant, Midland; **R. W. Lewis,** special tool joint representative, general sales department, Houston, Texas **H. M. Kelly,** West Texas-New Mexico division sales manager, Midland; **F. T. Alexander,** South Louisiana district sales manager, Lafayette, Louisiana; **Gayle Whiddon,** northern regional special representative, Tulsa, Oklahoma; **A. H. LeBleu,** southern regional special representative, Houston, and **Shelby Chambless,** Ark-La-Tex division special representative, Louisiana.

N. H. Erwin

A. W. Carroll

▸ **N. H.. (Nate) Erwin** has been promoted to general service manager, Pacific and mountain divisions of the McCullough Tool Company. His headquarters will be in Los Angeles, California.

▸ **A. W. Carroll** has been appointed a staff assistant at Dallas, Texas, in the engineering department of Otis Engineering Corporation, manufacturing affiliate of Otis Pressure Control, Inc.

▸ **D. R. Tashjian** has been appointed manager of engineering for the Westinghouse Electric Corporation's electronics division, Baltimore, Maryland.

▸ **Nicholas Weber** has been elected vice president in charge of all engineering activities for Condenser Service and Engineering Company, Inc.

▸ **John W. Branta** has been appointed supervisor of international motor truck advertising for International Harvester Company. **William A. Adler** has been named sales promotion supervisor.

Branta succeeds **Samuel E. Houston,** retired. **Robert B. McAllister,** supervisor of dealer advertising, assumes the editorship of "International Trail," a nationally circulated Harvester publication for motor truck fleet operators, in addition to his other duties.

E. M. Connor

R. E. Kimsey

R. W. Lewis

H. M. Kelly

F. T. Alexander

Gayle Whiddon

A. H. LeBleu

Shelby Chambless

▸ **John H. Flaskamper** has been advanced to the post of vice president of sales of American Bosch division, American Bosch Arma Corporation. He replaces **Donald H. Spicer,** who recently resigned to join Morse Chain Company as vice president in charge of sales.

▸ **J. T. (Sonny) Mobley** has been promoted to station manager at Hobbs, New Mexico, for Cardinal Chemical Company. Mobley replaced **Gene Swindle,** who has been transferred to Mobley's former Odessa station.

▸ **H. Gordon Smith,** executive vice president of United States Rubber Company, has also been elected vice chairman of the board and chairman of the executive committee. **Chester J. Noonan,** vice president, has been elected a member of the executive committee. **Herbert J. Reid** has been appointed assistant general manager of the mechanical goods division. Reid was formerly factory manager of the division's Fort Wayne, Indiana, plant. **Homer O. McCracken,** assistant factory manager, has been named to succeed Reid.

▸ **James B. Hughes** has been elected vice president of The Hydril Company of Los Angeles, California. He will continue to make his headquarters in Houston, Texas.

J. B. Hughes

C. M. Reagle

▸ **C. M. Reagle** has been assigned as district manager of the Cooper-Bessemer Corporation's New York domestic territory. Presently a vice president and director of Cooper-Bessemer, Reagle is also manager of marine sales for the company.

▸ **W. W. (Bill) Wilson** is regional sales manager in charge of the new Oklahoma City, Oklahoma, office of The Western Company. **R. N. (Dick) Brammer,** sales engineer, is to work with Wilson.

▸ **Bertram W. Mahoney** has been appointed general manager of the General Electric Company's industry control department. He succeeds **C. A. Salmonsen,** who will be assigned to special projects in other departments of the company.

▸ **John F. Dockum** and **Brooks M. Dyer** have been appointed managers of newly created sales groups for Columbia-Southern Chemical Corporation. Dockum has been named to head chrome chemical sales while Dyer will supervise the calcium chloride sales group. Assisting Dockum will be **Charles E. Grant,** who has joined the company's market development department. **T. D. Williams,** formerly field engineer for the Calcium Chloride Institute, will assist Dyer.

▸ **Charles Kuhn** has been appointed sales manager of the products division of Hills-McCanna Company.

Frank Stauffer has been named district representative of The Ohio Steel Foundry Company on the Pacific Coast. Stauffer will be active in Washington, Oregon, California, and British Columbia, Canada.

R. E. Burton has been made assistant general sales manager of The Koehring Company. In his new post, Burton succeeds **M. O. Messenger,** who recently was named vice president and sales manager for Koehring's Canadian subsidiary, Koehring-Waterous, Ltd., in Brantford, Ontario. In addition to his duties as assistant sales manager, Burton also will direct the distributor sales education program both in Milwaukee, Wisconsin, and in the field.

W. Samuel Carpenter III has been named assistant director of sales of the E. I. du Pont de Nemours & Company's petroleum chemicals division. Carpenter succeeds **M. H. Campbell,** who has been transferred to the new isocyanates sales section in the elastomers division. **Thomas J. Desmond** has been appointed Chicago district sales manager of Du Pont's Grasselli chemicals department, succeeding **W. James Latimore,** who will move to Wilmington, Delaware, on special assignment.

W. S. Carpenter

J. T. Tucker

J. T. (Tommy) Tucker has been made vice president in charge of sales of the George E. Failing Company. All other officers were reelected. **A. G. (Bud) Floyd** has been named manager of the Midland, Texas, branch of the company, where he replaces **Jimmy Helton.** Helton has been transferred to Edmonton, Canada, as manager of all Canadian operations for the company.

James A. Hughes has been elected treasurer of Diamond Alkali Company. Hughes will succeed **Arthur W. Crossley,** who plans to leave Diamond at an undetermined date, at which time he will announce his future plans.

Glenn O. Logan has been promoted to division manager of the Atlanta, Georgia, sales division of Cleco division of Reed Roller Bit Company.

Charles W. Lee has been appointed president of Consolidated Western Steel division of United States Steel Corporation. Lee will succeed **Alden G. Roach,** who is president of Columbia-Geneva Steel division of U. S. Steel.

Hosea P. Hearn and **Richard M. Hansen** have been elected vice presidents of Halliburton Oil Well Cementing Company. All other officers were reelected. Hearn was made regional vice president for Halliburton's central region, and Hansen was named vice president in charge of manufacturing.

J. P. Wiseman

J. G. Bounds

J. P. Wiseman, president of the Fluor Corporation of Canada, Ltd., for the past two and half years, has been named to head a newly established products company of the Fluor Corporation, Ltd. **J. G. Bounds** will succeed Wiseman as president of the Canadian affiliate of the Los Angeles, California, firm. Bounds has been vice president of Flour International, S. A., in Beirut, Lebanon. The appointments are effective November 1.

A. B. Quinn has been named president of Harrisburg Sales & Service, Inc. Quinn will replace the former president, **C. B. Caldwell,** who has resigned to become associated with Mid-Continent Supply Company.

Edward B. David has been appointed district manager of the new office of Welex Jet Services, Inc., in Farmington, New Mexico. **Roy H. Cossey** has been named sales engineer for the Welex district office at Shawnee, Oklahoma.

Jess A. McMurry has been named director of branches for Crane Company. His headquarters will be in Chicago, Illinois.

Ed C. Kirby has been appointed technical service representative for Ideco, a division of the Dresser Industries. His headquarters will be in Houston, Texas.

E. C. Kirby

W. W. Wolfe

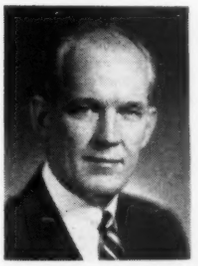
Warren W. Wolfe has been made manager of the Chicago sales office of the American Cast Iron Pipe Company, succeeding **Earl N. Mattson,** who has retired.

Raleigh Hortenstine, Dallas, Texas, president of Wyatt Metal & Boiler Works, has been elected chairman of the board. **Walter B. Van Wart,** executive vice president, was elected president, while **Inge Grant,** vice president, was given the post of manager of operations. Van Wart will continue with his headquarters at Houston, Texas. Grant, manager of the Dallas plant since 1940, will supervise operations of both plants, with Houston as headquarters. **John A. Wilson,** vice president, works manager, becomes manager of the Dallas plant.

L. A. Doan has been named assistant general manager of the western division of the Dow Chemical Company.

Dr. Richard L. Harvin has joined The Girdler Company as a process engineer in the Gas Processes division at Louisville, Kentucky. Girdler is a division of the National Cylinder Gas Company.

Charles N. Schmidt has been appointed general sales manager of The Western Company. His headquarters will be in Midland, Texas.



C. N. Schmidt

L. E. Colburn

L. Earl Colburn has been appointed technical sales manager for Poole-Pritchard, Ltd., engineers and constructors for the chemical gas and petroleum industries with offices in Calgary, Alberta, Canada.

J. E. Vogt has assumed the duties of secretary-treasurer of American Iron and Machine Works Company, Inc. He will replace **V. L. Thomas,** who has resigned.

J. E. Vogt

A. A. White

A. A. White has been appointed general service manager for Unit Rig & Equipment Company.

Jacques Gohier of Bethune, France, is in the U. S. to learn rotary drilling techniques. While here, Gohier is making his headquarters at the Enid, Oklahoma, plant of the George E. Failing Company, a subsidiary of Westinghouse Air Brake Company. He was sent to this country by his employers, C. Chartiez and Sons, drilling contractors operating in northern France.

James H. Joyner has been named manager, Pacific Coast sales, Quaker Pioneer Rubber Mills, division of H. K. Porter Company, Inc., San Francisco, California.

J. Richard Milliken has joined the metallurgical development division, Climax Molybdenum Company, New York City, as a specialist on the process industries and petroleum refining. Milliken will be located in the Pitttsburgh, Pennsylvania, office of Climax.

Trade Personals

James C. Dendy has been appointed assistant district engineer, machinery and equipment sales and service, at Greggton, Texas, for U. S. Steel's Oil Well Supply division. Three appointments in the West Texas area has been announced for Oil Well. **Edward Dwayne Andrus** has been named field representative at Anson, Texas. **J. R. Canon** has been appointed field representative at Hobbs, New Mexico. **Wylie Pressly Wright Jr.**, formerly field representative at Hobbs, has been transferred to Denver City, Texas. Two appointments in Southern Louisiana have also been made. **Kenneth Hodo** was named district representative at Lafayette, having served previously at the Eunice, Louisiana, store as field representative. **Henry H. Cooper** has been made field representative at Houma.

Arthur L. Frost, manager of the industrial division of Atlas Powder Company's engineering department, Wilmington, Delaware, has retired. He plans to make his future home in Florida.

BJ Service, Inc., has announced the following promotions within the company's sales and operating group: **Owen N. Andrew** has been appointed to the newly established post of sales manager. Andrew was previously Pacific Coast division operations manager. **James T. Streger** has been promoted from Pacific Coast division sales supervisor to Pacific Coast division manager of operations.

William D. Kent has been appointed sales engineer of S&R Tool and Supply Company of Houston, Texas.

Joe E. Ketner has been appointed vice president-general manager of Delta Tank Manufacturing Company, Inc., Baton Rouge, Louisiana. Three other vice presidents have been elected. These include **Ross B. Baze,** sales manager of Delta's oil field equipment and special order products division; **Max Fetty,** advertising and sales promotion manager, and **Jack Harelson,** manager of Delta's Macon, Georgia, plant.

Harry A. Burdorf, vice president and director of the Lunkenheimer Company, Cincinnati, Ohio, has retired after fifty years of service with the company.

R. Lindley Murray has been elected chairman of the board of Hooker Electrochemical Company, Niagara Falls, New York. Murray succeeds **Edwin R. Bartlett,** who resigned as board chairman to become chairman of the company's newly created finance committee. **Bjarne Klaussen,** formerly executive vice president, has been named president of the company.

Carl W. Eurenius, director of sales for Hercules Powder Company's cellulose products department, Wilmington, Delaware, has been appointed assistant general manager of the department. **Werner C. Brown,** an assistant director of sales in the department, was named to succeed him as director of sales.

Thomas H. Smith has been placed in charge of public relations and industrial relations for Sivalls Tanks, Inc., Odessa, Texas.

John A. Jost has joined Kewanee-Ross Corporation (Ross Heater division), Buffalo, New York, as heat exchanger development engineer.

G. Allen Lovell has been elected a vice president of United States Rubber Company and appointed general manager of its mechanical goods division, New York City. He was formerly assistant general manager of the division. **Wilbur E. Combs** has been named sales promotion manager of industrial rubber products for U. S. Rubber with headquarters in New York. Combs had been assistant manager of sales development.

H. E. Tracy has been named manager and **D. F. Strang** product manager of the newly expanded mechanical seal product division of Byron Jackson Company.

S. G. Sevougian has been appointed manager of the Framingham, Massachusetts, plant of The Dow Chemical Company. It was also announced that **Frank Kottek,** who held the title of production manager at Framingham, has been named a consultant to the plant manager. Sevougian was production superintendent at Framingham prior to his new appointment.

Roscoe J. Lyons has accepted the appointment as president of Pipelife Corpotion, which recently moved its national headquarters to Tulsa, Oklahoma, from San Angelo, Texas. Lyons' home was in Pasadena, California.

Douglas C. Lance has been appointed as sales promotion and advertising manager of Axelson Manufacturing Company, division of U. S. Industries, Inc.

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CASING COUPLINGS A.P.I.
4 1/2" to 13 3/8"—Long or Short
HYDRAULIC COUPLINGS
1/8" to 4" — Seamless
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Albany, N. Y.—Albert L. Becker, 434 Clinton Ave.
Baltimore, Md.—Ted Barto, 2301 No. Charles St.
Chicago, Ill.—Harry A. Jay, Suite 1090, Old Colony Bldg.
Detroit, Mich.—Thomas L. Osberger, 10226 Woodward Ave.
Erie, Pa.—R. J. Maggi, Box 711
Falmouth, Mass.—Walter S. Bennett, 53 Minot St.
Houston, Tex.—Henry H. Paris Distributor, Inc., Box 932
Los Angeles, Cal.—James A. Riordan Co., 1400 Santa Fe Avenue
Milwaukee, Wis.—M. A. Nelson Co., 3347 N. 97th St.
Minneapolis, Minn.—Lin J. Krause, 5605 Lyndale Ave. S.
Narberth, Pa.—J. W. Worthington, 105 Forrest Ave.
Newark, N. J.—Ira L. Rothenberg & Assocs., Industrial Office Bldg., 1060 Broad St.
New York, N. Y.—Max Rothenberg, 11-05 38th Ave., Long Island City
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
St. Louis, Mo.—Mike A. Boyle Co., 1112-18 Hamilton Ave.
San Francisco, Cal.—Earl H. Jones & Co., 1150 Folsom St.
Seattle, Wash.—Earl H. Jones & Co., 819 Thomas St.
TOP QUALITY Since 1918
WHEELING MACHINE PRODUCTS COMPANY
WHEELING, WEST VIRGINIA
Factories at WHEELING, W. VA. and WOODLAKE, CALIFORNIA

Dr. William H. Bowman has been appointed assistant general manager of the organic chemicals division, American Cyanamid Company. He had been a vice president of Jefferson Chemical Company, Inc., since 1951. Jefferson is jointly owned by American Cyanamid Company and The Texas Company. **Dr. Norman A. Shepard** has retired from his post as chemical director of American Cyanamid.

Republic Supply Company of Los Angeles, California, has announced the establishment of a refinery sales department to be headed by **Joseph W. Coffy**, with **Chet W. Horstmann** as assistant. **J. W. Breyer** has been transferred to Los Angeles city oil sales. **A. G. Thorpe** has been promoted to branch manager at Santa Maria while **T. W. Hoyer** has been advanced to salesman at Ventura. New store supervisor at Newhall Ranch is **S. J. Stoulp.**

H. W. Severance has been appointed sales engineer for Western Supply Company in the Louisville, Kentucky, and Ohio Valley areas.

Henry W. Rojas has been named vice president of export marketing for Witco Chemical Company.

Allison C. Neff, vice president of Armco Drainage & Metal Products, Inc., Middletown, Ohio, has been named the new president of the National Society of Professional Engineers. Neff is a past president of both the Cleveland and the Ohio Societies of Professional Engineers, and a past national director of the NSPE.

Jack W. Rembe has been elected vice president of the Rodney Hunt Machine Company, Orange, Massachusetts. He will also continue as sales manager.

Claude E. Davis has been named manager of packing and special products sales for the Goodyear Tire & Rubber Company, Akron, Ohio. He had been on special development work for the company's industrial products division.

Executive Vice President **William P. Drake** will succeed **George B. Beitzel** as president of the Pennsylvania Salt Manufacturing Company, Philadelphia, Pennsylvania. Beitzel will continue his association with the company as a member of its board and in addition, will serve as chairman of the board of the Pennsalt International Corporation, a subsidiary. At 42 years of age, Drake will be the youngest president in Pennsalt's 105-year history, and with 21 years' service prior to assuming office, he will have longer company experience than all but one of his thirteen predecessors.

C. G. A. Rosen, president of the Society of Automotive Engineers has been honored by Bradley University, Peoria, Illinois, in recognition of his preeminence in the field of science and engineering throughout the world. He was awarded an honorary Doctor of Science degree. Rosen has received wide acclaim for his part in the development of the diesel engine, having been in charge of the original Caterpillar Tractor Company program that developed a diesel engine for tractors. He is now consulting engineer to the president of Caterpillar. Rosen is a lecturer on the faculty of Stanford University.

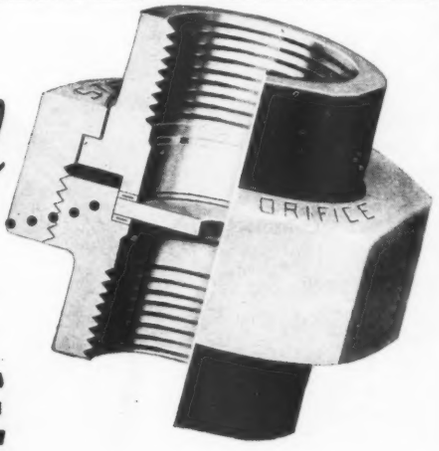
FOR THE BEST IN

Flow Control

INSIST UPON

C.M.& CO.

ORIFICE



After quick and easy installations, even in the roughest spots, these ORIFICE UNIONS will perform superbly in measuring, mixing, blending, strainer or blanking off services. Their temperature and pressure ratings are exceedingly high. They are available in forged steel, forged stainless steel and with the new tab on the orifice plate that facilitates quick identification.

OUR COMPLETE LINE OF FORGED STEEL UNIONS IS FULLY DESCRIBED IN A NEW CATALOG. WRITE FOR YOUR FREE COPY!

Clayton Mark & Company

1900 DEMPSTER STREET EVANSTON, ILLINOIS U.S.A.

It's Amazing!

THE TOLEDO NO. 78 VERMETTE POWER DRIVE

★ WEIGHS ONLY 75 POUNDS
A real heavy-duty, lightweight

★ RAPID, POSITIVE CHUCKING
Grips like a pipe wrench—self centering

★ CONSERVES TIME AND ENERGY
The most advanced and versatile machine on the market

★ BETTER BUILT TO LAST LONGER
No belts — sturdy — powerful

A time proved, PORTABLE power drive providing effortless cutting, threading and reaming of pipe and conduit . . . a worthy addition to "TOLEDO's" well known line of quality pipe tools. Fully guaranteed. Handles up to 2" sizes . . . grips, tightens and centers pipe automatically, forward or reverse. It's the lightest portable power drive of its kind. And remember . . . if it bears the "TOLEDO" label . . . you know it's a dependable product.

Write today for new free bulletin with conclusive proof of superiority. Your "TOLEDO" supplier has all the facts.

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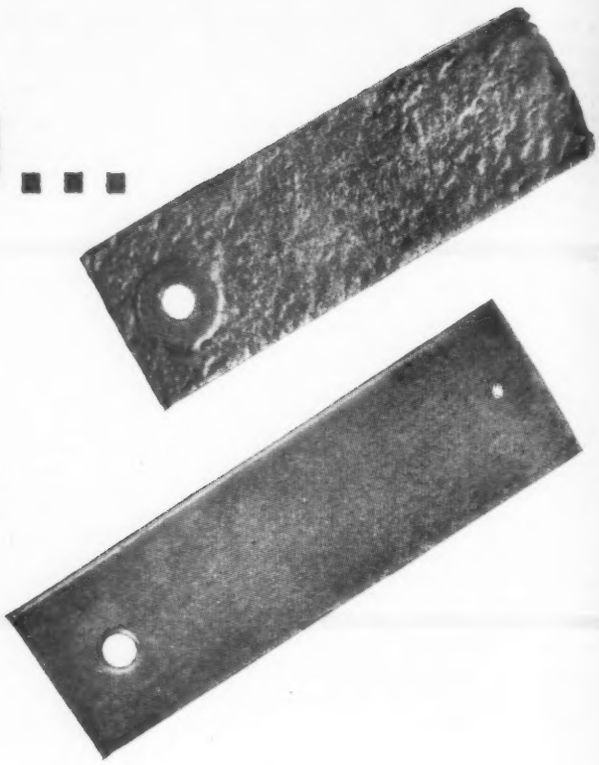
BUILDERS OF THE WORLD'S FINEST PIPE TOOLS

TOLEDO®

PIPE THREADERS • PIPE WRENCHES • PIPE MACHINES

before...



...and after

with *Visco* corrosion control!

HERE are several sets of typical before and after coupon test figures in wells now getting Visco Anti-Corrosion Treatment. Estimate the *tons* of well equipment metal saved by Visco Treatment, and you get an idea of the *dollars* saved in labor and replacement costs . . .

Well	Maximum Weight Loss—Mils/year	
	Before Visco	With Visco
1.	11.00*	0.02
2.	4.90	0.40
3.	8.10*	0.86
4.	7.50	0.08
5.	16.00*	1.30

** These wells receiving "anti-corrosion" treatment. Replaced by Visco.*

1 mil=.001 inch. A corrosion rate of 216 mils per year means that the corrosive attack, if uniform, would have corroded away the entire surface of the metal to a depth of .216 inches in a year. However, the real danger of high corrosion rates, as the coupon shows, is the much deeper and faster penetration occurring at localized areas.

These are not super-success figures. Chances are high that Visco can equal or better these results in *your* wells. Phone, Houston, MAdison 3-0433, collect, or write for positive Visco action today.

VISCO PRODUCTS COMPANY
Incorporated
2600 Nottingham at Kirby • Houston 5, Texas

***Visco*®... CONSISTENTLY EFFICIENT OIL FIELD CHEMICALS**

NEW oil and gas Equipment

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

- machinery
- supplies
- services

(1) TUBULAR STEEL WRENCH

Stilsomatic offers a pipe wrench called the Stilsomatic "Red Snapper." It institutes four unique features: (1) Tubular steel construction (2) automatic adjusting, fulcrum action (3) spring loaded hook jaw, and (4) light weight.

The Stilsomatic Sales Corporation.

Circle number (1) on reply card.

(2) GAS-PROPANE CARBURETOR

The Ensign Model Mgl, made in ¾ in. and 1 in. SAE sizes is rated at 60-hp capacity. It will handle engine requirements from 16 to 60 hp. Designed for natural gas and propane, it is capable of handling lower Btu manufactured gas because of its interchangeable venturi features.

Ensign Carburetor Company.

Circle number (2) on reply card.

(3) ENCLOSED MOTOR

Century Electric Company has announced its Totally Enclosed Fan-Cooled Motor Line in the 7½ to 100 hp series. Motors were developed for use in dirty, dusty fumes and mist-laden atmospheres that could damage ordinary motors.

Century Electric Company.

Circle number (3) on reply card.

(4) WISCONSIN ENGINE

In the lightweight, 4-cycle, heavy-duty engine field, Model ACN heads up the Wisconsin line as the smallest engine in a current series of 12 models, rated from 5.6 to 36 hp. Model ACN has a piston displacement of 14.88 cu in., and is designed to operate within a speed range of 1600 to 3600 rpm, delivering from 2.3 to 5.6 hp.

Wisconsin Motor Corporation.

Circle number (4) on reply card.

(5) CURB PUMP FILTERS

A curb pump filter for removing abrasive solids from diesel fuel and gasoline being pumped from storage tanks to vehicles has been developed by Purolator. Filter, designated the PAG-25D duel fuel filter, is designed to catch abrasive solids and prevent damage to expensive close-tolerance injection parts and engine components.

Purolator Products, Inc.

Circle number (5) on reply card.

(6) STEAM TRAP

Type TD-50 steam trap, for pressures 10-600 psi, uses the thermodynamic energy of steam to close the valve. Machined from stainless steel bar stock, this TD-50 steam trap consists of only three parts: Body, screwed cap, and the valve head, a solid stainless steel disc.

Sarco Company. Inc.

Circle number (6) on reply card.

(7) MOBILE POWER UNIT

The "MO-BIL-AC," a portable source of a-c power, delivers up to 10 kw at 110-220 v and greatly extends the use of power tools and motor-driven machinery in locations away from power lines or during power failures. Utilizing as a prime mover the engine of the vehicle in which it is carried, the unit supplies alternating current at commercial voltages and frequencies, single or polyphase.

Star-Kimble Motor division, Miehle Printing Press & Manufacturing Co.

Circle number (7) on reply card.

(8) SMALL ELECTRIC MOTORS

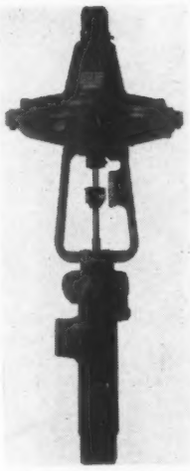
The A. O. Smith Corporation is in production on a line of fractional horsepower jet pump motors that feature totally enclosed canopy housings that protect the vital parts from dirt, insects, or rodents. Motor switch, starting capacitor, and automatic overload protector all are conveniently end-mounted and protected by the enclosed canopy. The units are available in single and three-phase ⅓ through 2 hp in models for either horizontal or vertical applications.

A. O. Smith Corporation.

Circle number (8) on reply card.

In Drilling-Producing . . .

(9) PRESSURE REGULATOR



BS&B has introduced the Type 2815-DRT Regulator, a special application of the BS&B Diaphragm Control Topworks with the Thornhill Craver Unibolt choke to provide automatic control of the reduced pressure delivered by valve. Working pressure is 5000 psi and test pressure, 10,000 psi.

The valve is a standard 2-in. heater choke, furnished with a special inner valve stem and hub assembly.

Black, Sivalls and Bryson, Inc.

Circle number (9) on reply card.

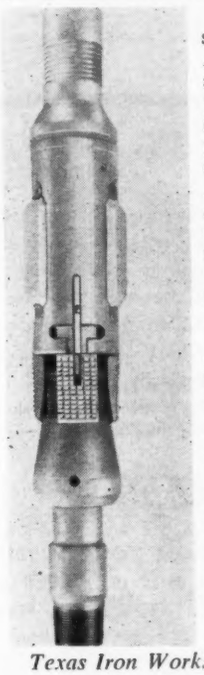
(10) PLASTIC COATED WIRE ROPE

A plastic coated cable, "Plasteel," has been announced by Macwhyte Company. Cable is either a preformed galvanized steel or stainless steel wire rope, coated with strong, tough, flexible plastic. The thickness of the plastic coating varies with the diameter of the rope. It is resistant to most acids, bases, salts, oils, and greases.

Macwyhte Company.

Circle number (10) on reply card.

(11) TUBING ANCHOR



The T-I-W Tension-Type Tubing Anchor was designed to hold the tubing of a pumping well in tension to prevent movement of the tubing string. Anchor is strictly mechanical in function and provides means of release when it is desired to remove the tubing from the well.

Anchor is set in a conventional manner by right-hand rotation and landing tubing in tension. It may be released by slacking weight off and re-paying slips or by right-hand rotation, with slips set. Rotating disengages anchor by mechanically moving the cone from beneath the slips.

Texas Iron Works.

Circle number (11) on reply card.

(12) OIL WELL HEATER

A heating device, manufactured jointly by N. W. Curson Associates and General Electric, literally melts its way through the paraffin barrier found in low-producing wells. The 18-ft long heater assembly includes six 80-in. Calrod heater units sealed in oil-tight pipes that are lowered into the well shaft.

N. W. Curson Associates of California and General Electric Company.

Circle number (12) on reply card.

(13) FROTH ANCHOR

To correct froth conditions evidenced by pump efficiency of 40 per cent or less, froth anchor has been introduced by Agate Anchor. In addition to separating oil and gas, manufacturer states Anchor corrects rough pumping action, creation of a tight emulsion in the tubing, and the heading of production at the surface caused by gas.

Agate Anchor Sales Company.

Circle number (13) on reply card.

(14) KEY-SEAT CUTTER

A key-seat cutter designed to ream out troublesome key seats, assuring clear passage for drill collars when round tripping, is being made by Servo. Tool consists of a 3-stage, sleeve-type reamer mounted on a heavy steel mandrel. It is designed for use between the top drill collar and the bottom drill pipe joint. Cutter is provided with a release to permit jarring should the cutter become stuck.

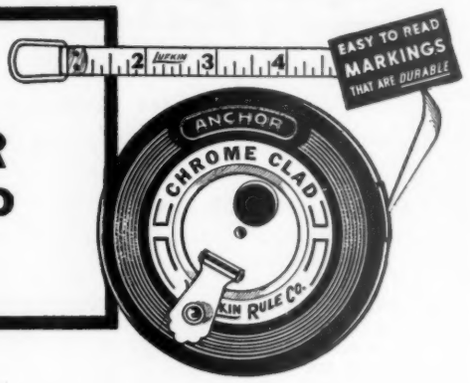
The Servco Company.

Circle number (14) on reply card.

No-glare, easy reading — the oil industry's favorite for years . . .

LUFKIN

ANCHOR CHROME CLAD STEEL TAPE



Jet black markings on the Lufkin "Anchor" Chrome Clad are bonded to the tempered steel line and stand out sharp and clear against the no-glare, chrome-white background. The "Anchor" is strong, and durable too, because the line is built up with a series of platings for extra protection and strength. Genuine leather, mahogany-colored, is hand-stitched over rust-resistant metal case liner. Folding flush handle opened by push pin. A fine tape combining strength, durability, accuracy and beauty. Available with graduations either in feet, 10ths and 100ths; or feet, inches and 8ths.

BUY LUFKIN 361

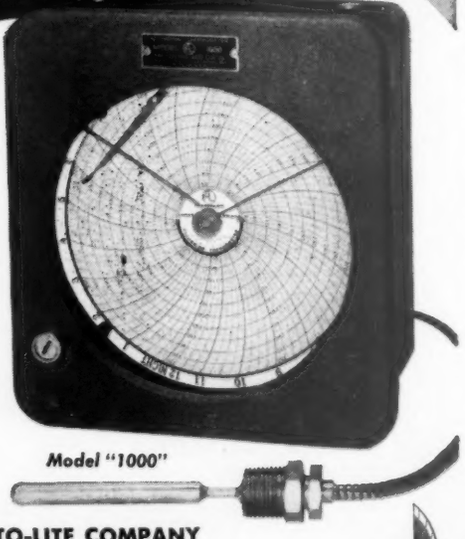
TAPES • RULES • PRECISION TOOLS
FROM YOUR SUPPLY STORE
THE LUFKIN RULE CO., SAGINAW, MICHIGAN
132-138 Lafayette St., New York City • Barrie, Ontario

AUTO-LITE

TEMPERATURE RECORDING . . .

Newly designed, Model "1000" Auto-Lite Recorder gives permanent proof of temperature behavior. • 6" clear reading chart; various standard ranges from minus 40°F. to plus 550°F. • 3 standard types; choice of 24-hr. or 7-day cycle. • Electric or mechanical chart drive. • With capillary tubing for remote reading. Priced from $49.50.

Send for new catalog describing many styles of Auto-Lite temperature Recorders and Indicators.



Model "1000"

THE ELECTRIC AUTO-LITE COMPANY
INSTRUMENT AND GAUGE DIVISION
TOLEDO 1, OHIO
NEW YORK • CHICAGO • SARNIA, ONTARIO

TEMPERATURE RECORDERS

New Equipment

(15) OFF-HIGHWAY TRUCK

A four-wheel drive, light-duty truck, model R-120 (4x4), has been introduced by International Harvester. Gross rating is 7000 lb. It is offered in four wheelbases between 115 and 134 in. and is powered by 108 hp International Silver Diamond 220 engine.

International Harvester Company.

Circle number (15) on reply card.

(16) LANDING NIPPLE PACKER

Otis has announced the "Selective" Collet-Type Casing Packer, which employs a landing nipple principle similar to that used for Otis sub-surface controls. The assembly consists of four principal units. A casing nipple, a packer body, a seal nipple and locator sub. Any length of stringer, including upset tubing and couplings, may be run through standard-sized packers.

Otis Pressure Control, Inc.

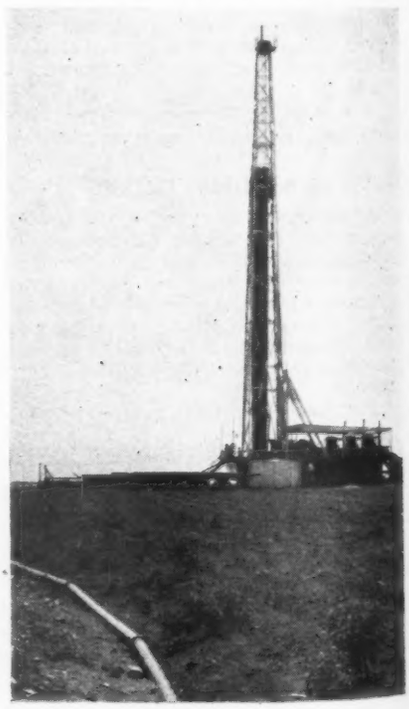
Circle number (16) on reply card.

(17) ALUMINUM PIPE LINE

Aluminum line pipe for oil field use has been announced by Kaiser Aluminum. Employing quick-connecting couplers, pipe is designed for rapid laying and pick-up of lines by regular oil field crews. Three different couplers are available from Gateway Engineering, Industrial Coupler, and Warren Manufacturing companies. Pipe is marketed in 2, 3, and 4-in. sizes and has a rating of 500 psi. Picture shows water line supplying a drilling on the Texas Plains.

Kaiser Aluminum and Chemical Corporation.

Circle number (17) on reply card.



In Refining . . .

(18) PACKAGED PH SYSTEM

Beckman Instruments has announced the availability of a "packaged" pH control system. Designed for use in any pH process application, this system combines in a single package all components needed for single or multiple-channel pH process monitoring, recording, and controlling. Entire system is built at the factory, wired, piped and assembled ready for plug-in installation.

Beckman Instruments, Inc.

Circle number (18) on reply card.

(19) SERVO MOTOR

A 35-w, 2-phase a-c servomotor-tachometer generator unit that operates on 60 cycles has been announced by Diehl. This unit can be used to regulate the speed of a motor or to stabilize closed-loop circuits. With the motor and tachometer mounted on a single shaft, back-lash is zero.

Diehl Manufacturing Company.

Circle number (19) on reply card.

(20) FUEL OIL HOSE

Thermoid has announced availability of a new fuel oil hose with a synthetic rubber cover compounded to resist abrasion when dragged over concrete, cut stone, and rough rocky ground. The cover of the "Fuelmaster" hose will not mark concrete walks, driveways, or decks.

Thermoid Company.

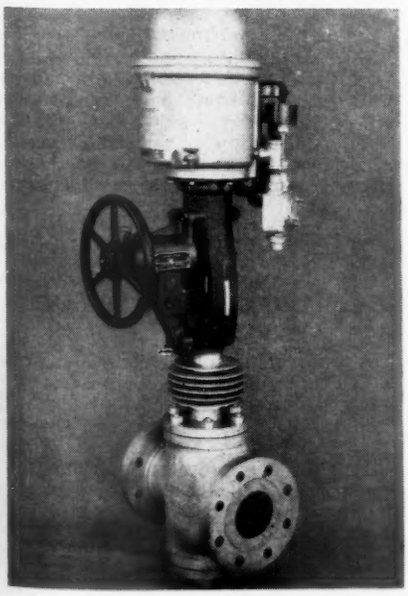
Circle number (20) on reply card.

(21) REMOTE OPERATOR

Manning, Maxwell & Moore has announced a self-contained Electro-Hydraulic Control Valve Operator that does not require air supply or compressor systems. Control valve operator is entirely operated by electrical power.

Manning, Maxwell & Moore, Inc.

Circle number (21) on reply card.



(22) SPRAY HEAD

The Stearns Gyrospray is designed to produce a controlled spray of evenly divided water particles at pressures under 5 psi. In cooling towers the Gyrospray pattern will cover the width of a standard horizontal cooling section without water loss, and on vertical coils it gains maximum effieciency by the use of dual baffle boards. Rotor is molded from inert, resilient nylon and is not affected by the chemical action of any of the inhibiting additives used in industrial cooling water.

N. C. Stearns Company.

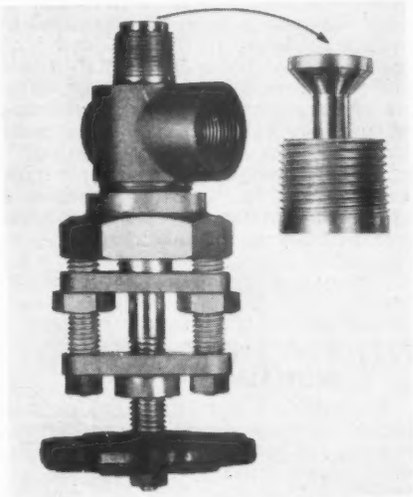
Circle number (22) on reply card.

(23) AUTO-STOP METER

Two Auto-Stop meters with double-trip, Auto-Stop valves for positive control of industrial liquids are being offered by Neptune Meter. Automatic deliveries of water, oils, solvents, and other liquids to batching and blending processes are accomplished with accurate cut-off and minimum hydraulic hammer even when handling high rates of flow. The quantity desired is set by pushing buttons, and the meter shuts off the flow automatically when the exact quantity is delivered.

Neptune Meter Company.

Circle number (23) on reply card.



(24) SAMPLING VALVE

Drain or Sampling Valve No. 23 announced by Jerguson is completely self draining, for the valve stem seat is on the outside of the valve body. It is designed for installations where it is desirable to have the valve seat inside the wall of a vessel in order to prevent liquid from remaining in the nipple and valve.

Jerguson Gage & Valve Company.

Circle number (24) on reply card.

(25) HIGH-PRESSURE SEALERS

High-pressure sealing devices, tradenamed Seelskrews and Hexseals, are available in two versions from the manufacturer. Seelskrews consist of a standard machine screw with a built-in O-ring under the head. Hexseals are switch "boots" that fit over standard push-button, rotary, and toggle switches, replacing the usual panel locknut. Both devices are designed to prevent the entry of dust, moisture, combustible vapors or other contaminants into an enclosure.

Automatic & Precision Manufacturing Company.

Circle number (25) on reply card.

In Pipelining . . .

(26) TORQUE REDUCER

A planetary-gear torque reducer that permits "one-man" operation of Hills-McCanna's 10-in., 12-in. and 14-in. Saunders Patent Diaphragm Valve has been introduced. The torque reducer provides a 5 to 1 mechanical advantage and is available on either handwheel or chain-operated valves.

Hills-McCanna Company.

Circle number (26) on reply card.

(27) BRUSH CUTTER

Attachment that converts the Homelite Model 17 chain saw into an all-purpose brush cutter has been announced. According to the manufacturer, the brush cutter makes quick work of clearing large areas overgrown with brush, weeds, and small saplings.

Homelite Corporation.

Circle number (27) on reply card.

(28) AUTOMATIC SAMPLER

Introduced recently, the MEPCO Pipe Line Sampler is designed to take accurate samples from the pipe line automatically. Operating entirely from line pressure, sampler takes samples in direct proportion to the rate of flow.

McFarland Engineering and Pump Company.

Circle number (28) on reply card.

(29) SMALL ACTUATOR

A small electrically powered actuator with a driving force of 55 lb is being manufactured by the New Haven Clock. Unit is adaptable to the remote closing of oil pipe line valves.

New Haven Clock & Watch Company.

Circle number (29) on reply card.

(30) ENGINE-DRIVEN WELDER

A 200-amp, engine-driven welder, designed for pipe line welding and all types of construction and maintenance work, has been announced by the General Electric Company welding department. Designated Type WD20AG, the new welder is NEMA-rated for a current range of 40-250 amp and will handle all d-c or a-c/d-c electrodes from 1/16 in. to ¼ in.

General Electric Company.

Circle number (30) on reply card.

NEW oil and gas Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

- brochures
- bulletins
- catalogs

(31) INFRARED ABSORPTION

A new bulletin describing analysis of materials by infared absorption method is now being distributed by Electrical Testing, New York City. All organic and many inorganic compounds, regardless of their complexity, have a characteristic infrared absorption spectrum. Purity, presence of key materials, or minor components in a complex mixture can be determined qualitatively and quantitatively by comparison with known standards. Factors limiting the use of this method have been scarcity of this type of spectroscope and lack of trained personnel.

Electrical Testing Laboratories.

Circle number (31) on reply card.

(32) FUME SCRUBBERS, HEAT TRANSFER

A bulletin issued by Schutte and Koerting contains illustrations and complete technical details on the company's line of fume scrubbers and "packaged" scrubbing systems. This equipment employs water or other suitable liquid as the scrubbing agent for the control of fumes or dust and is adaptable for the handling of solid particles, liquid particles, or gases. Another bulletin recently issued highlights representative products in the company's line of heat transfer equipment.

Schutte and Koerting Company.

Circle number (32) on reply card.

(33) HIGH PRESSURE EQUIPMENT

High Pressure Equipment's new catalog fully describes its line of high-pressure valves, adapters, reactors, autoclaves, thermo-couplings, gages, fittings, and tubing.

High Pressure Equipment Company, Inc.

Circle number (33) on reply card.

(34) ROADABLE RAIL-CAR SWITCHER

HemcO Manufacturing has announced new literature describing important changes in its new model HemcO-Motive. The HemcO-Motive is a roadable-type, railcar switcher that utilizes the box cars weight, through weight transfer, to obtain traction. The HemcO-Motive is now equipped with a coupler that gives positive connection between the HemcO-Motive and the rail car. The Positive Coupler also allows the HemcO-Motive to couple with ease to either side. Another important improvement is a fluid drive, which relieves the operator of tricky coordination usually needed to start heavy loads. Fluid drive also saves power train from sudden shock load, which means lower maintenance. The HemcO-Motive develops a draw bar pull of 7400 lb, which under average conditions is sufficient to propel 3 fully loaded cars.

HemcO Manufacturing, Inc.

Circle number (34) on reply card.

(35) PACKAGED STEAM GENERATORS

A 16-page catalog has been issued on new series of Foster Wheeler packaged steam generators in sizes 10,000 to 46-000 lb steam per hour. Catalog gives capacities, dimensions, construction features, instrumentation, accessories, sectional drawings, installation photographs, chart for selection of firing equipment and controls, and a typical proposal.

Foster Wheeler Corporation.

Circle number (35) on reply card.

(36) HORIZONTAL FILTERS

A bulletin has been issued describing new features that speed up operation and simplify recovery of disposal of filter cake now being built into Industrial's line of horizontal filters. These include a quick-opening, hydraulically operated and sealed door, and filter leaves that lift out and snap back into place without bolts. An optional vibrating attachment shakes off the filter cake, eliminating the need for scraping or shaking by hand. Standard features also include power or manual withdrawal of leaf assembly, completely exposing all the leaves; bottom outlet; air drying facilities, and optional leaf spacing.

Circle number (36) on reply card.

(37) AUDIO FREQUENCY SIGNALING

North Electric has a low-cost signalling system designed specifically to fill expanding sub-audio or d-c signaling needs, which is described in a four-page bulletin. System utilizes either frequency shift or frequency modulation for transmitting signaling information. Permits teletype, telegraph, telemetering, and other sub-audio or d-c signaling to be multiplexed over open wire, telephone carrier, radio, microwave, or any system capable of carrying voice frequencies. Bulletin contains photographs and specifications of system.

North Electric Company.

Circle number (37) on reply card.

(38) TWIN CRAWLER TRACTOR

The Euclid TC-12 Twin Crawler Tractor, powered by two 194-hp diesel engines, is described in a 4-page, 4-color catalog released by Euclid division of General Motors. This catalog describes the revoluntionary design of this tractor with its two engines and separate Torqmatic Drives for each track that give it a total of 365 hp delivered to the power train. Other unusual features illustrated are rear radiator mountings, separate and independent track drives, and hydraulic track tension.

Euclid division, General Motors Corporation.

Circle number (38) on reply card.

(39) HYDRAULIC TRANSMISSION

A brochure on the Gerotor Variable Speed Hydraulic Transmission has been released.

Gerotor May Corporation.

Circle number (39) on reply card.

(40) DEHYDRATION UNIT

An eight-page bulletin on the Pritchard Hydryer has been re-issued. The Hydryer is a packaged dehydration unit for efficient drying of air or other gases in all industrial, processing, and laboratory installations.

The J. F. Pritchard & Company of California.

Circle number (40) on reply card.

(41) ROLLING BEARINGS

A 52-page illustrated bulletin has been issued featuring the new SCM line of ball-bearing pillow blocks, and flange cartridge mounts. It also contains up-to-date technical information and list prices on the complete line of Dodge SC ball and Dodge-Timken roller bearings.

Dodge Manufacturing Corporation

Circle number (41) on reply card.

(42) PURGE METER

A new illustrated bulletin in color describes advanced concept in metering small flows of liquids or gases with the newly designed Sho-Rate "50" Purge Meter. Complete description of various models and accessories together with capacity charts and dimension drawings are included in the bulletin.

Brooks Rotameter Company.

Circle number (42) on reply card.

(43) DIRECT-FLOW PUMP

A new bulletin from Aldrich Pump covers the design, operation, and advantages of the company's "Powr-Pac" 2½-in. stroke, direct-flow pumps. This 4-page, 2-color bulletin uses photographs and line drawings to illustrate pump construction and operation. The "Powr-Pac," smallest of the Aldrich line of direct flow pumps, is designed for installations that heretofore were forced to use larger pumps than were actually needed.

Aldrich Pump.

Circle number (43) on reply card.

(44) CORROSION-RESISTANT VALVES

A 4-page illustrated bulletin describing Monel and nickel corrosion-resistant valves has been published by Alloy Steel Products. The new bulletin discusses the corrosion-resistant properties of Monel and nickel, listing specific applications for which each is suited. Included in the bulletin are cross-sectional illustrations of gate, globe, and check-type valves.

Alloy Steel Products Company, Inc.

Circle number (44) on reply card.

(45) HOIST CLASSIFICATION

A hoist classification rating chart has been published and released by the Truck Body and Equipment Association. The material and data in the chart was compiled by the engineering committee representative of all of the major hydraulic hoist and steel dump body manufacturers, members of and comprising an industry division within the TBEA. This chart, the only one of its type, has been published to provide a means of standardizing the capacity ratings and as a convenient method of comparison of hoists manufactured by the association members. The chart places all hoists in classes depending upon the torque rating in inch-pounds developed by the hoist around its hinge shaft. Also included in the chart is a table for determining the size of rating of hoist needed for any anticipated use. Body dimensions and payload tonnage figures are used in the table, which converts that information into the required hoist class needed for the given job.

The Truck Body and Equipment Association, Inc.

Circle number (45) on reply card.

(46) SCREENING CATALOG

The 1955 SWECO Separator catalog features photos, drawings, and detailed specifications of equipment and successfully screens more than 241 different materials. A complete data file will accompany this catalog with information directly pertinent to the interests of each inquirer.

Southwestern Engineering Company.

Circle number (46) on reply card.

(47) DRY DESICCANT DEHYDRATOR

Black, Sivalls & Bryson has announced publication of a new catalog on the improved Model DDH Dry Desiccant Dehydrators. New design features of the DDH include exclusive horizontal sorbers for easier installation and increased desiccant efficiency. The unit is completely automatic requiring no outside power sources for operation although local utilities can be used when available. A BS&B Salt Bath Heater furnished high regeneration gas temperatures at maximum safety. Automatic cycling of the sorbers is provided with BS&B's 3-way switching valves.

A characteristic claimed for the new DDH is its ability to produce pipe line specifications when processing gas at high inlet temperatures or low inlet pressures. The catalog is illustrated with photographs and color flow diagrams.

Black, Sivalls & Bryson, Inc.

Circle number (47) on reply card.

(48) NEW SWIVELS

Ideal swivels, Types N-35, N-47, and N-69, three of the six sizes in a new line offered by National Supply, are presented in three new 8-page bulletins published by the company. These swivels are usually selected when drilling between 300 and 9000 ft. Design features and specifications are given.

The National Supply Company.

Circle number (48) on reply card.

(49) CHEMICAL CLEANING

New Dowell service bulletin presents pertinent data regarding techniques used in the chemical cleaning of catalytic cracking equipment.

Dowell Inc.

Circle number (49) on reply card.

(50) WIRE ROPE USES

The correct use of wire rope in rotary drilling and cable tool drilling is described in a 64-page catalog published by the Wire Rope Corporation of America, Inc. The company's "Ton-Mile Calculator" included in the catalog is a slide chart that figures ton miles for all standard drill pipe sizes.

Wire Rope Corporation of America.

Circle number (50) on reply card.

(51) LIFT TRUCK SELECTION

A new kind of industrial equipment analysis guide and rating table similar to job and personnel rating techniques has been introduced by Hyster for comparison and selection of fork lift trucks. The plan, known as "How to Select a Lift Truck," is based on user evaluation of job requirements and truck features by points with a chart and analysis guide. Thirty-six lift truck features are listed for comparison under the following headings: Performance, ease of operation, durability, serviceability and appearance. As many as four trucks can be analyzed and compared on the chart.

Hyster Company.

Circle number (51) on reply card.

(52) ENGINEERING DATA BOOK

Publication of a 16-page stainless steel Engineering Data Book has been announced by Cooper Alloy. Compiled for use as part of the new Cooper Alloy Catalog, the Engineering Data section includes design and dimensional information on flange drilling templates, flange and ring-joint facings, stainless steel pipe, pipe threads, thread engagement, pressure-temperature ratings and conversion factors, resistance of fluid flow, hardness conversion tables, metal casting factors, physical and mechanical properties of stainless steel, and a detailed materials selection chart covering more than 300 corrosive solutions.

Cooper Alloy Corporation.

Circle number (52) on reply card.

(53) RECORDING CHARTS

A bulletin outlining the methods and controls used in producing recording instrument charts has been released by The Bristol Company. The 14-page 2-color bulletin shows some of the tests and quality control procedures that go into the manufacture of charts for its own recording and controlling instruments as well as for specialty instruments for other manufacturers.

The Bristol Company.

Circle number (53) on reply card.

(54) ENGINE-GEAR SET

"Nordberg Supairthermal Engine-Gear Set," an eight-page bulletin concerning centrifugal compressors and high speed pumps has been announced by Nordberg Manufacturing Company. The pamphlet describes the advantages of the Nordberg V-type engine-gear set for use on large capacity gas pipe lines. Illustrations show the engine-gear set driving a centrifugal compressor, and the details of the Nordberg-built speed increasing gear.

Nordberg Manufacturing Company.

Circle number (54) on reply card.

(55) PRESSURE-RATED PIPE

Showing how and where its lightwall, high impact, pressure-rated oil country pipe is used to combat corrosion, is discussed in a folder released by Alpha Plastics, Inc. The folder shows how maintenance problems can be minimized in handling sour crudes and salt water by using rigid, pvc pressure-rated plastic pipe. A properties chart showing special characteristics of the pipe, together with ratings on its high impact and tensile strength and aging qualities, are included.

Alpha Plastics, Inc.

Circle number (55) on reply card.

(56) STRAIN GAGES

A price list for SR-4 strain gages, instruments, accessories, and cements, with revised quantity discounts, is announced by Baldwin-Lima-Hamilton Corporation. The 12-page booklet includes specifications for all sizes and types of bonded resistance wire strain gages, and tells how to select the right gage to meet various conditions of use.

Baldwin-Lima-Hamilton Corporation.

Circle number (56) on reply card.

(57) SPECTROPHOTOMETERS

An eight-page brochure on types of recording spectrophotometers manufactured by Beckman Instruments, Inc., has been released. The booklet details the requirements for a variety of quantitative and qualitative applications, and recommends the particular type of instrument for each use.

Beckman Instruments, Inc.

Circle number (57) on reply card.

(58) POTENTIOMETER

Wheelco's portable potentiometer, a unit designed to give extreme accuracy in checking installations of temperature measurement and control instruments, in in Barber-Colman Company's bulletin both the laboratory and field, is detailed F5760-1. Readable to .025 mv, the scale length of the instrument exceeds 40 in. Models are available with a built-in run-up box and calibrated rheostat for line resistance compensation.

Barber-Colman Company.

Circle number (58) on reply card.

(59) RUBBER GOODS

Hewitt-Robins, Inc., has issued a catalog of molded rubber goods and industrial sheet packing. The rubber goods section contains a specification chart comparing the qualities of six types of natural and synthetic rubber used in molded products. The industrial sheet packing section lists 10 types of all-purpose pure gum and synthetic rubber sheet packing and the recommended uses for each.

Hewitt-Robins, Inc.

Circle number (59) on reply card.

(60) SHEAVES

Stationary and motion control Vari-Pitch sheaves for speed variations up to 76 per cent by a pitch diameter adjustment, capacities 1-600 hp, are described in a bulletin released by Allis-Chalmers Manufacturing Company. The bulletin gives a table of sizes and general dimensions of the sheaves, and a table of general dimensions of Paraline ball-bearing motor bases.

Allis-Chalmers Manufacturing Company.

Circle number (60) on reply card.

Trade Literature

(61) DUPLEX PUMPS

Power duplex pumps are described in five 8-page bulletins issued by The National Supply Company. The bulletins show increases in horsepower ratings ranging from 80 to 600 hp, and give design features, performance charts, and specifications.

The National Supply Company.

Circle number (61) on reply card.

(62) PETROLEUM RESINS

Brochure covering Kermac Resin 641 has been made available by Keer-McGee Oil Industries. Information includes physical properties, process, and applications of product.

Kerr-McGee Oil Industries, Inc.

Circle number (62) on reply card.

(63) BRONZE FILTERS

Sintered bronze, filter material gaining acceptance in petroleum and natural gas processing and bulk handling, is explained and illustrated in a catalog by the Permanent Filter Corporation.

Permanent Filter Corporation.

Circle number (63) on reply card.

(64) COMPRESSOR

An 8-page, 2-color booklet emphasizing Ingersoll-Rand's 3R-36 cfm self-contained Spot-Air portable compressor has been released. On-the-job illustrations show the advantages of a lightweight compressor. The flier also enumerates the tools Spot-Air will operate.

Ingersoll-Rand.

Circle number (64) on reply card.

(65) MAGNATROL CATALOG

Magnatrol Valve has recently published a catalog illustrating and describing its complete line of electrically controlled magnetic valves.

The Magnatrol Valve Corporation.

Circle number (65) on reply card.

(66) HEAT EXCHANGERS

Stainless steel heat exchangers for heating or cooling liquids and gases used in chemical, pharmaceutical, refining, and allied processing industries, are described and illustrated in Young Radiator Company's Catalog No. 1155.

Young Radiator Company.

Circle number (66) on reply card.

(67) CHLORINATOR

Proportioneers, Inc., division of B-I-F Industries, Inc., has issued a color bulletin on its heavy duty midget Chlor-O-Feeder for chlorinating private and camp water supplies, swimming pool water, and sewage in septic tanks.

Proportioneers, Inc.

Circle number (67) on reply card.

(68) ABRASIVE CUTTER

A four-page, two-color bulletin on Speed-Cut abrasive cutting machine has been released by Beaver Pipe Tools, Inc. Featuring both the No. 14 (bench type) and No. 20 (floor type) models, the bulletin includes data on cutting time for various shapes and types of materials.

Beaver Pipe Tools, Inc.

Circle number (68) on reply card.

(69) HYDRAULIC PUMPS

New York Air Brake Company offers an illustrated bulletin, DP-320, describing its series PFM-100 dual vane hydraulic pumps designed to meet special conditions of service encountered on mobile equipment applications. The PFM-100 is designed for high speed direct engine drive, and can be operated continuously at 2000 psi and at maximum speeds from 2000 to 2600 rpm depending upon pump size. The brochure includes comprehensive selection data, showing flow rates, and horsepower input for four sizes at selected operating speeds.

New York Air Brake Company.

Circle number (69) on reply card.

(70) STOCK INSTRUMENT

Process control instruments standardized and stocked for immediate shipment are described and illustrated in Fischer and Porter's 24-page catalog 2.

Fischer and Porter Company.

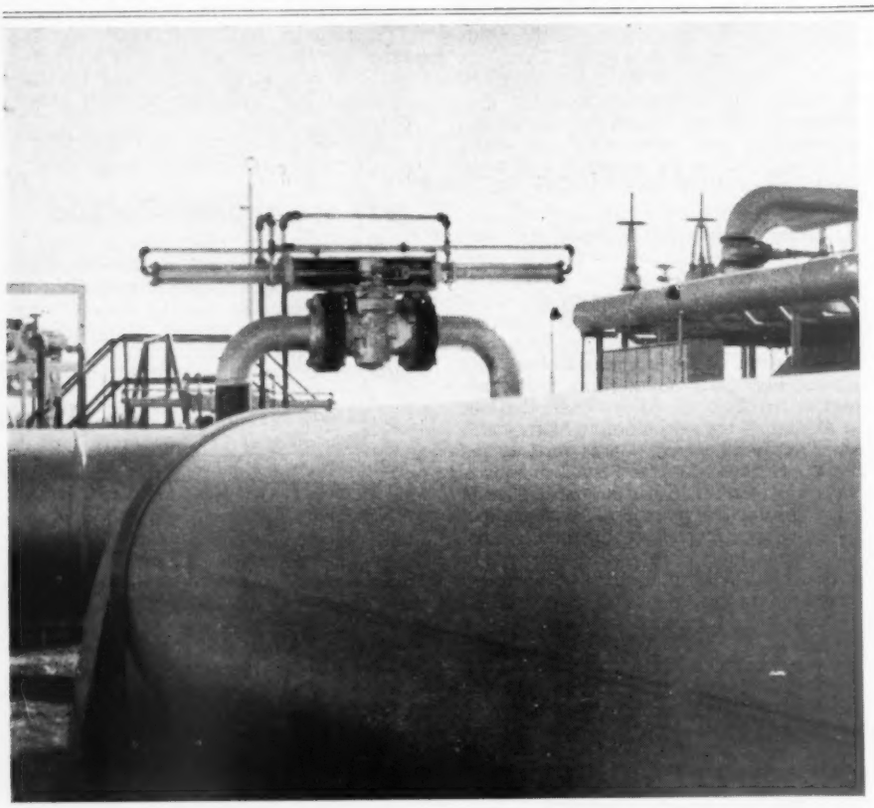
Circle number (70) on reply card.

(71) V-ANGLE COMPRESSOR

A 24-page engineering bulletin describing the V-angle engine-driven compressor has been released by The Cooper-Bessemer Corporation. The bulletin provides technical data on developments in compressor design for improving fuel economy and increasing capacity and range of operation.

The Cooper-Bessemer Corporation.

Circle number (71) on reply card.



AUTOMATIC BLOWDOWN SYSTEM FOR COMPRESSOR STATION OPERATED BY LEDEEN VALVE ACTUATORS

New AGA Code Revision Specifies Emergency Shutdown Facilities...

"Each transmission compressor station shall be provided with an emergency shutdown system by means of which all gas compressing equipment, all gas fires, and all electrical facilities in the vicinity of gas headers and in the compressor building can be shut down and the gas can be blocked out of the station and the station gas piping blown down." (per Paragraph 843.431, Emergency Shutdown Facilities, Revision of Section 8 of ASA B31.1).

WRITE FOR BULLETIN 3020.

VALVES • CYLINDERS
VALVE ACTUATORS
AIR HYDRAULIC
PUMPS & BOOSTERS

Ledeen Mfg. Co.
1608 San Pedro St.
Los Angeles 15, Cal.

(72) GAGE ILLUMINATORS

Jerguson liquid level gage illuminators are illustrated in a two-page pamphlet describing solid-Wedge type illuminators. Also described and pictured is the UL-approved explosion-proof lighting unit.
Jerguson Gage and Valve Company.
Circle number (72) on reply card.

(73) IH POWER UNIT

An eight-page booklet describing the UD-1091 power unit has been published by International Harvester Company. The booklet contains full specifications, photographs, and performance charts on the UD-1091, as well as descriptions of available attachments.
The unit is the largest diesel model in International's line of 18 heavy duty power units.
International Harvester Company.
Circle number (73) on reply card.

(74) FLEXIBLE PIPING

An eight-page bulletin, "How to Solve Piping Flexibility Problems," has been published by Barco Manufacturing Company. Bulletin shows swing joints and flexible ball joints as used in tank truck loading and unloading lines, and steam-jacket ball joints.
Barco Manufacturing Company.
Circle number (74) on reply card.

(75) CENTRIFUGAL PUMPS

"Worthite Centrifugal Pumps for Acids, Alkalies, and Slurries," a 20-page bulletin by Worthington Corporation, includes information and outline drawing of Worthite pumps with standard stuffing box, photographs of open type impellers, parts list and diagram of standard mechanical seal, and complete information on application and construction modifications.
Worthington Corporation.
Circle number (75) on reply card.

(76) FLAME PHOTOMETER

A four-page, three-color brochure describing operation of model 146 flame photometer for analysis of alkali metals in solution has been published by The Pedkin-Elmer Corporation.
The Pedkin-Elmer Corporation.
Circle number (76) on reply card.

(77) WELDING MANUAL

A 32-page technical manual, "A New Welding System," has been published by Metal and Thermit Corporation. The manual is a guide to the use of Murex Crolov chrome-moly electrodes for welding piping and equipment subjected to high temperature or high pressure service.
Metal and Thermit Corporation
Circle number (77) on reply card.

(78) AUTOMATIC CONTROLS

General Controls Company has released its catalog of automatic industrial controls. Products are so grouped that all information needed about each item is readily available.
General Controls Company.
Circle number (78) on reply card.

(79) ROYSTON PRODUCTS

Royston Laboratories, Inc., has published a folder including 9 pieces of literature on its products. This folder, with literature pocket and file tab, is designed to fit standard file drawers and serve as a handy reference to Royston products.
Royston Laboratories.
Circle number (79) on reply card.

(80) VENTILATION UNITS

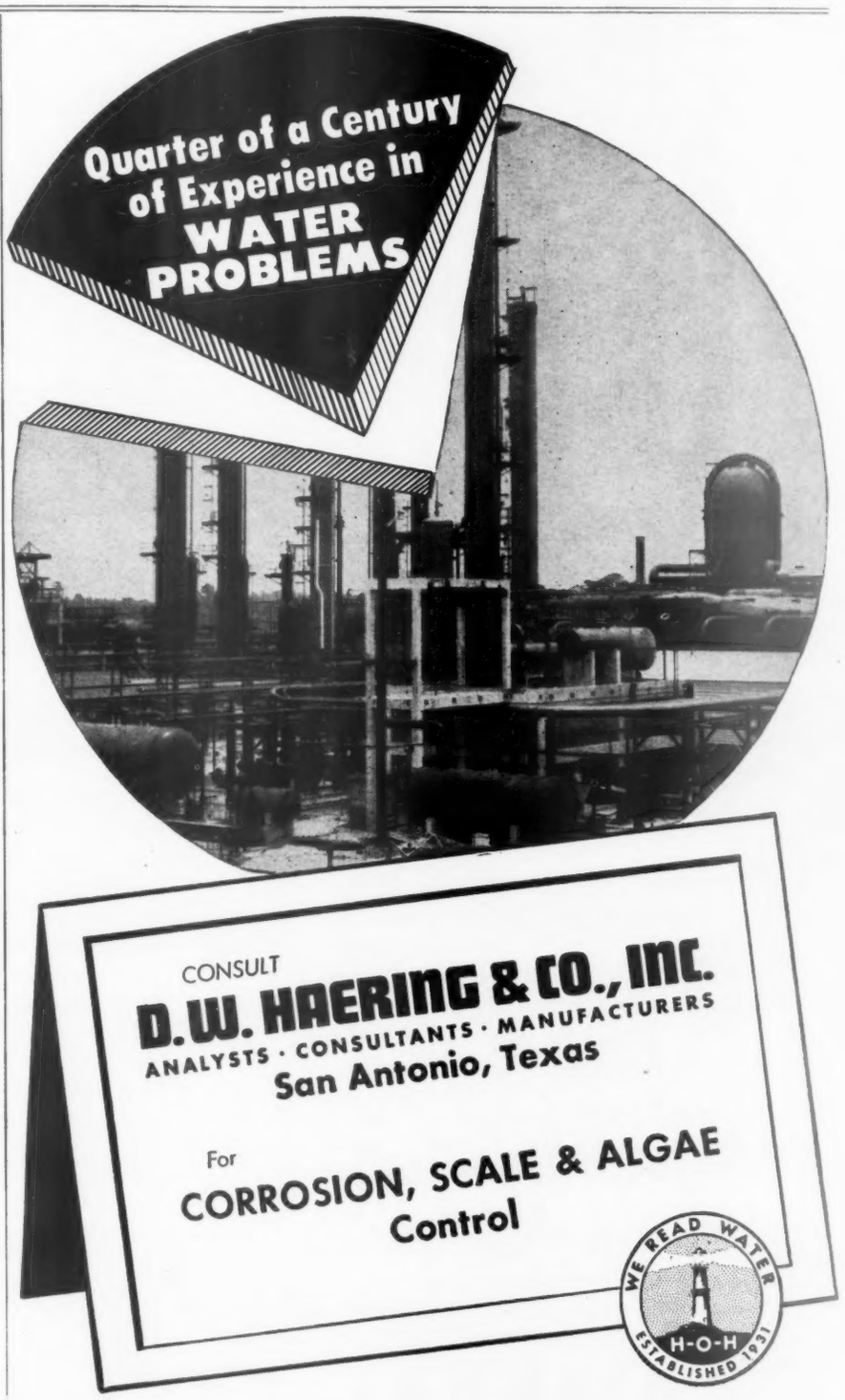
A two-color, four-page condensed catalog of components of the Autronic control system has been announced by The Swartwout Company. The catalog illustrates and gives a brief description of the function and working principles of each unit in the Autronic control system.
The Swartwout Company.
Circle number (80) on reply card.

(81) ZINC CONTROL OF CORROSION

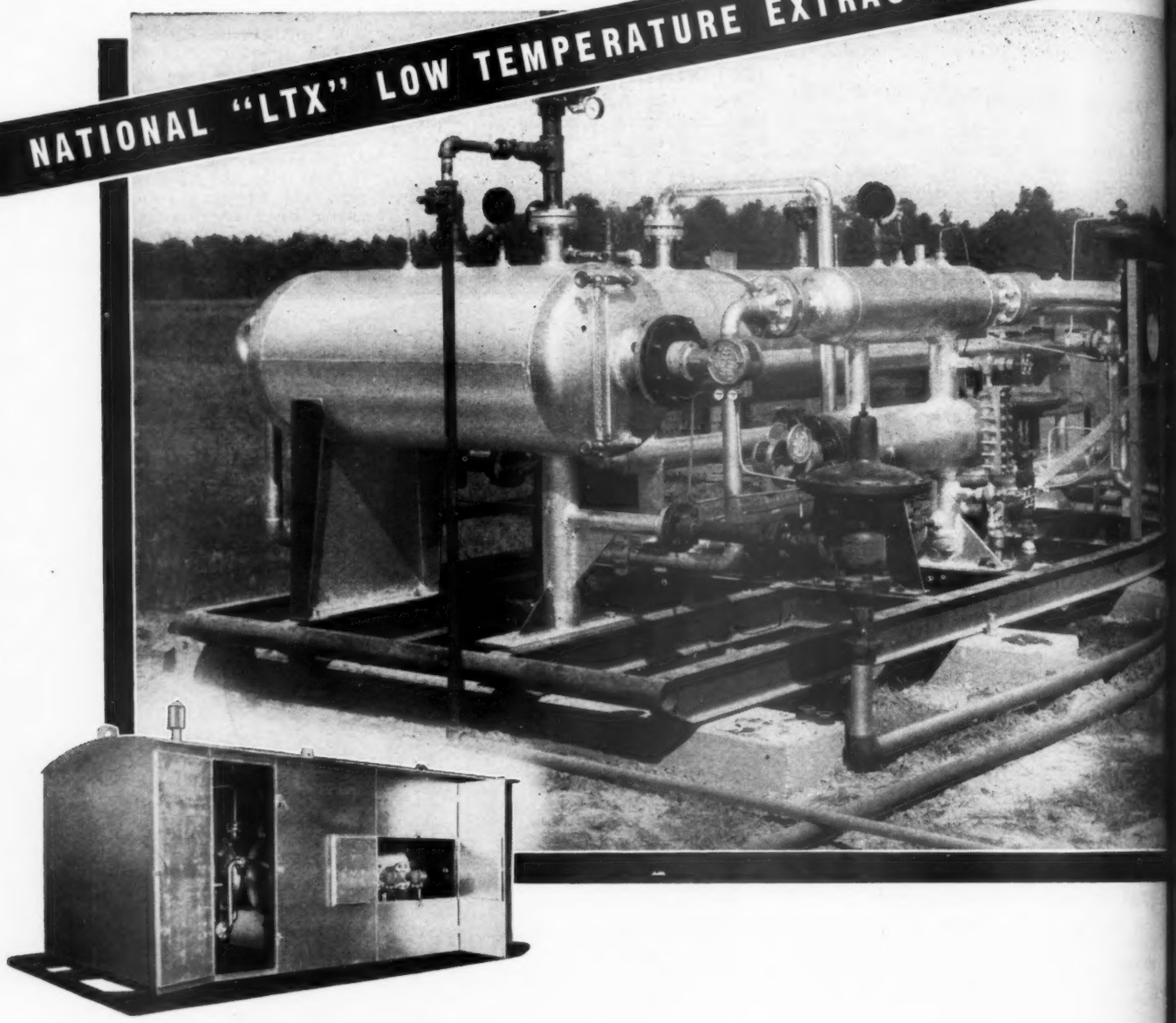
"How Zinc Controls Corrosion," 32-page illustrated booklet, has been published by the American Zinc Institute. The booklet describes the many ways zinc lengthens the life of steel products.
The American Zinc Institute.
Circle number (81) on reply card.

(82) COMPRESSORS

Gas-engine-driven compressors in the 330-to-660-hp range are the subject of a bulletin released by Ingersoll-Rand Company. This 44-page bulletin covers all the engine-driven compressors.
Ingersoll-Rand Company.
Circle number (82) on reply card.



NATIONAL "LTX" LOW TEMPERATURE EXTRACTION UNITS



Products engineered by National Tank Company are so designed that they become universal for the task they are appointed to do. "Universal" because they are not tailor-made to fit only one set of conditions. They will do the work on many jobs within their rated maximum capacities.

Many "Firsts" have come from "National" — One of the Latest Firsts is the LTX — Low Temperature Extraction Unit.

National LTX Units Produce Maximum Results at Minimum Costs: 1. Maximum Pressure and Flow Stream Recovery of Stable Distillate. 2. Minimum Water Dew Point of Final Gas Stream; Minimum Hydrocarbon Dew Point.

National LTX Units are made in various sizes and capacities.

Write for further information.

"LTX" IS A REGISTERED TRADE-MARK.

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TULSA, OKLAHOMA

Finest

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52 Vanderbilt Avenue, New York

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Editorial Assistant

BETTE RUTH HORTON
Editorial Assistant

DON FICKERT
Presentation Editor

•

ADVERTISING STAFF

NEW YORK — JOHN WALLACE
52 Vanderbilt Ave., MUrray Hill 4-1880

CHICAGO — E. V. PERKINS
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LETTERS

Waterflood Comparisons

An article describing the Maracaibo Oil Exploration Corporation's Bush City, Kansas, waterflood appeared in *The Petroleum Engineer* for June, 1955, on page B-79. This article is of special interest to us at California Research Corporation because it contains information which makes possible the comparison of waterflood recovery calculated by engineering methods with that observed in the field. To be most useful, however, we feel that a little additional information concerning initial water saturation and relative permeabilities is needed.

We would like, therefore, to communicate with the author of this paper in order to find out whether or not additional information can be made available . . .

R. F. Faull.

Laboratory Director,
La Habra Laboratory
California Research Corporation
La Habra, California

Plaudit for 'Pipe Line Book'

We wish to acknowledge receipt of your letter of August 26, which arrived with our copy of your "Pipe Line Handbook."

The book has only been here about 10 or 15 minutes but even a cursory examination seems to reveal a great deal of material which will be of interest to us and we are particularly glad to have the copy which you have so kindly forwarded. *E. E. Jurs.*

Shand and Jurs Company
Berkeley, California

★ ★ ★

Please . . . send us 21 copies of the "Pipe Line Handbook." We are sending a copy to each of our branch offices and ask them the quantity they feel they could use to advantage. . . .

Advertising Director *E. R. Bonnist.*
The Cooper-Bessemer Corporation

Safety Engineer Uses Series

I have recently had the opportunity to look over your release entitled "Fundamentals of Rotary Drilling," and would like very much to commend the editors of that release on their comprehensiveness and clarity.

In my work as a safety engineer, I find that this release would be extremely valuable to me as a reference, and to our new engineers in familiarizing them with the aspects of drilling.

I would like very much to obtain two or three copies of this release, if they would be made available for individual purchase. Will you please advise me as to whether or not I could obtain these copies, and if so, what the price would be.

Ed Arnold.

Safety Engineer
Liberty Mutual Insurance Company
Oklahoma City 2, Oklahoma

Note: This is just one of hundreds of letters commending the "Fundamentals of Rotary Drilling" series. Copies are available at $1.50.

Bottom-Hole Pressures

I wish to thank you for the tear copies of the recent article "How to Determine Static Bottom-Hole Pressure from Surface Measurements." I will be pleased to send these prints to the co-authors along with the honorarium which was recently received from Editor-in-Chief Frank Love.

You may be interested in knowing that as a result of the article we received requests from petroleum engineers engaged in many phases of the gas industry. These included engineers with large companies, small companies, banks, consulting and testing companies and professional consultants.

Paul B. Crawford.

Assistant Director,
Texas Petroleum Research Committee
A and M College
College Station, Texas

'Rig Locator' Accepted

I have just looked over your drilling rig listing called "Drilling Rig Locator" and find it most interesting and informative. It is a step in the right direction and the fact that it is not complete should not discourage you too much.

Doubtless the next publication of this original idea will include most of the rigs not listed in the first effort. At any rate the information is interesting to me and I believe the industry will accept it for its fine basic values.

Brad Mills.

Executive vice president,
American Association of
Oilwell Drilling Contractors
Dallas, Texas